JMatPro User's Guide

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1 Installation

1.1 System requirements

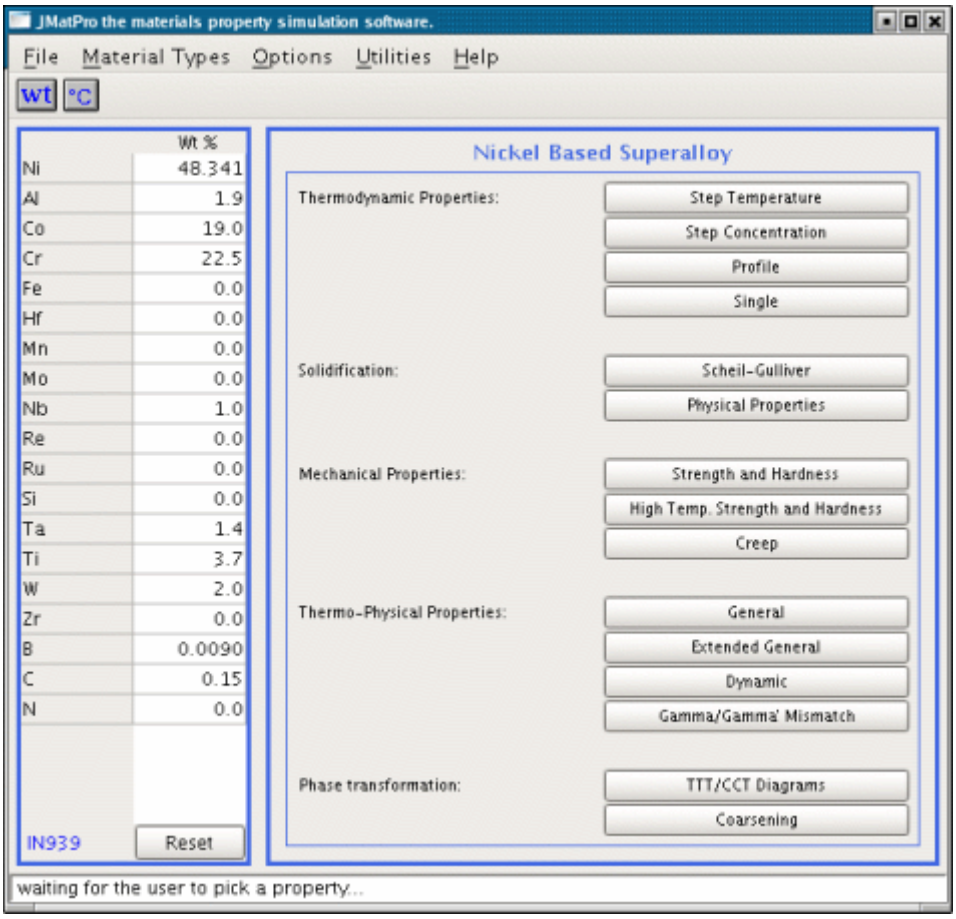
In order to run JMatPro efficiently, a minimum configuration should be:

- Pentium IV or equivalent.
- 256Mb RAM.
- Screen resolution is expected to be 1024x768 pixels or better. A smaller resolution would probably lead to very ugly oversized windows. A minimum size of 17 inches for the screen is recommended to work comfortably with multiple windows.

JMatPro has been tested under Linux for x86, Windows 98, Windows NT4 Windows 2000 and Windows XP.
Although JMatPro runs under Windows ME, this operating system is not recommended because of some glitches in the graphics.
JMatPro will not run under anymore under Windows NT 3.x.

2 User Interface

2.1. the main input window...



Quick Start:

- To work on a new material choose the base type in the Material Type menu and type in the composition of this material.
- To work on a material which composition has been stored go to the Load Composition item in The File menu.
- To browse through properties in saved material files go to the Load Material File item in the File menu.
- On the toolbar use the At Wt buttons to choose Weight(Wt) or Atomic(At) percentage for composition input/output.
- On the toolbar use the °C K F buttons to choose your preferred temperature unit.
- Choose a property from the list of properties available.

File menu:

- Load Material File: load a file with precalculated properties for a given material with a given composition.
- Load Composition: initialise composition table with a previously saved composition.
- Save Composition: save the composition which is in the current composition table.
- Rebuild Indexes: if the program looses track of the saved material files, this will rebuild the indexes in use for fast file location.
- Exit: Exit the program.

Material Types menu:

- this brings up a menu from which to choose the type of material you wish to work with. Once a material is chosen, a default composition table and a list of the properties you can calculate are brought up.

The Options menu:

This menu gives you a high level of control on many settings of the program.

- **Run in verbose mode/Run in quiet mode** : verbose mode shows you what is going on but SLOWS THINGS DOWN A LOT, keep it Quiet under normal circumstances.
- **Record session/Stop recording** : record to a file the program activity, this will become useful when you encounter a problem and want to provide us with all the info we need to help you. This slows things down as well.
- **General Preferences**
    - **Reference states** : define reference states for Partial Gibbs energies and Activities.
      (Not integrated yet, Standard Element Reference is used by default).
    - **HTML and PDF readers** (not all platforms) : define the applications to use to read help files.
    - **Printing** : define printing preferences (paper size).
    - **Fonts** : define font preferences (color,size,style) for graphs.
- **Order of elements** : define the order of the elements in the composition table.
- **Show phase boundaries search control** : If this option is selected the input window for calculations of thermodynamic properties (Stepping/Profile) includes a new checkbox which allows the disabling of phase boundaries search. This can become very useful when the solver finds it difficult to locate a given phase boundary and if this exact temperature (or concentration) pont is not required.

All other submenus depend on the calculation modules installed with the program.

The Utilities menu:

- Conversions: perform unit conversions and, if the Strength and Hardness module is integrated, conversions between 0.2% Proof Stress, Tensile Stress and Hardness.
- Create material type: allows the user to create a new material type with a restricted set of elements and phases.

Help menu:

- About: information about JMatPro.
- Contents: brings up the index of the inline documentation.
- Quick-start: brings up the help file you are currently reading.
- FAQs: Frequently asked questions.
- License terms and conditions.

The Tool Bar:

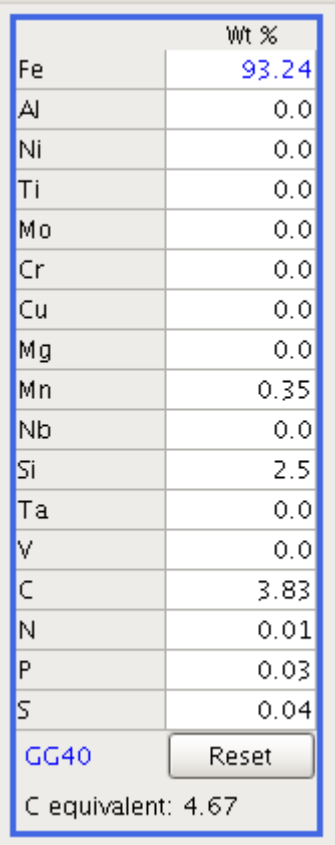
-

switch between atomic and weight percentage for the material composition.
-

switch between temperature units.
-

this button will appear once a property has been chosen and will enable you to come back to the full list of properties for the current material type.

The composition table:



	Wt %
Fe	93.24
Al	0.0
Ni	0.0
Ti	0.0
Mo	0.0
Cr	0.0
Cu	0.0
Mg	0.0
Mn	0.35
Nb	0.0
Si	2.5
Ta	0.0
V	0.0
C	3.83
N	0.01
P	0.03
S	0.04

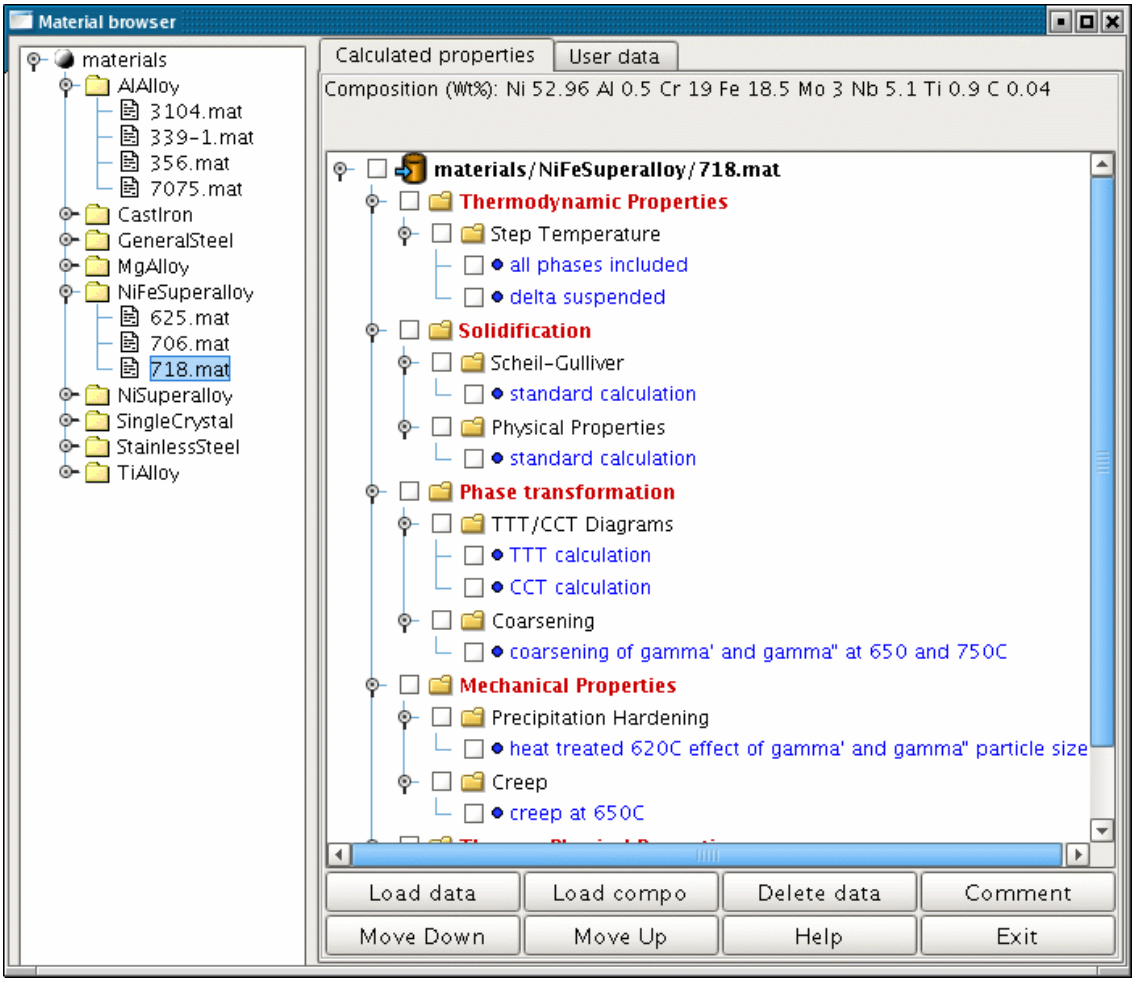
GG40 Reset

C equivalent: 4.67

- At the bottom of the composition table you will find a "Reset" button which resets the composition to 100% of the balance element.
- If the current composition comes from a saved composition or material file, the name of the composition or of the material file will appear at the bottom of the composition table.
- For Cast Iron, another field is displayed, and updated as the composition changes, to show the Carbon Equivalent Number (CEN). The CEN is calculated based on the following formula: CEN=%C+(%P+%Si)/3 with this formula a CEN of 4.3 characterises an eutectic alloy while a lower value denotes a hypoeutectic alloy and a greater value a hypereutectic alloy.

2.2. JMatPro User's Guide: the material browser...

This browser allows easy navigation through collections of material files.
Each material file has a unique signature which is the elemental composition identifying a material. Material files are meant to hold all the property calculations made for a material. The format of these files is designed in order for the browser to classify in a tree form all the saved datasets for different properties. The browser can be used to retrieve datasets in an easy way.



Left Panel:

The left panel allows easy navigation through the material files via a tree-like representation.
- left click on a material file will display the saved properties in this file.
- right click on a material file will display a pop-up menu which allows to delete this file or to rename it.

Top Right Panel:

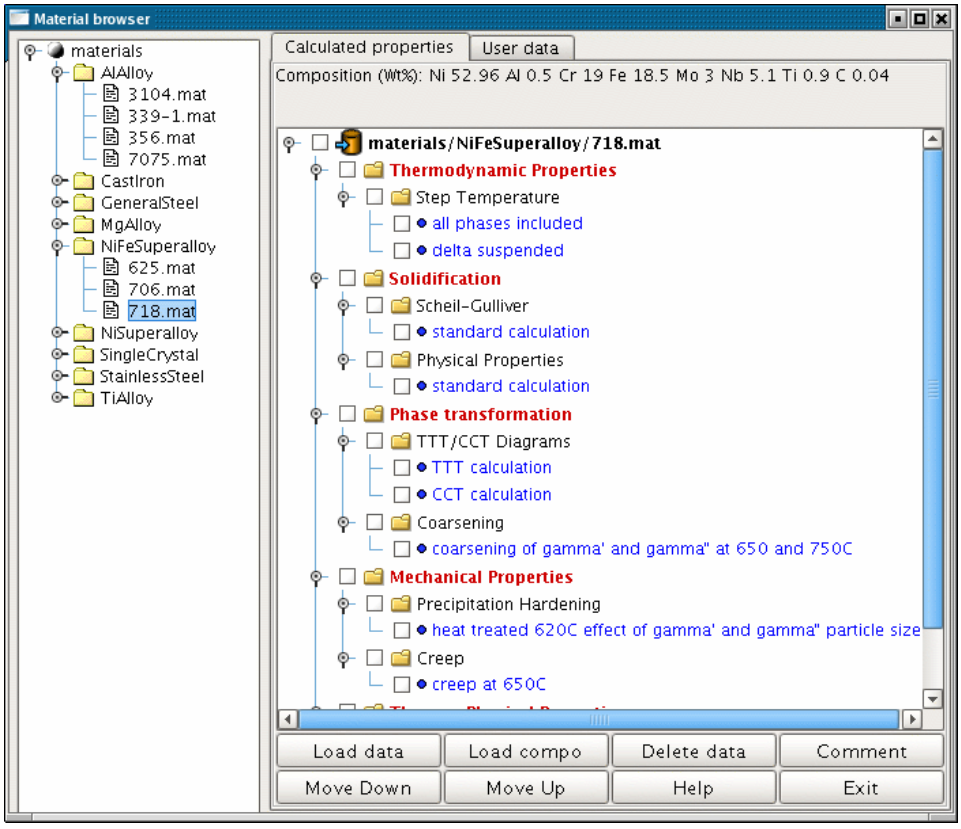
The right top panel gives valuable information about the material file:
- composition
- user comment

The Datasets Tree:

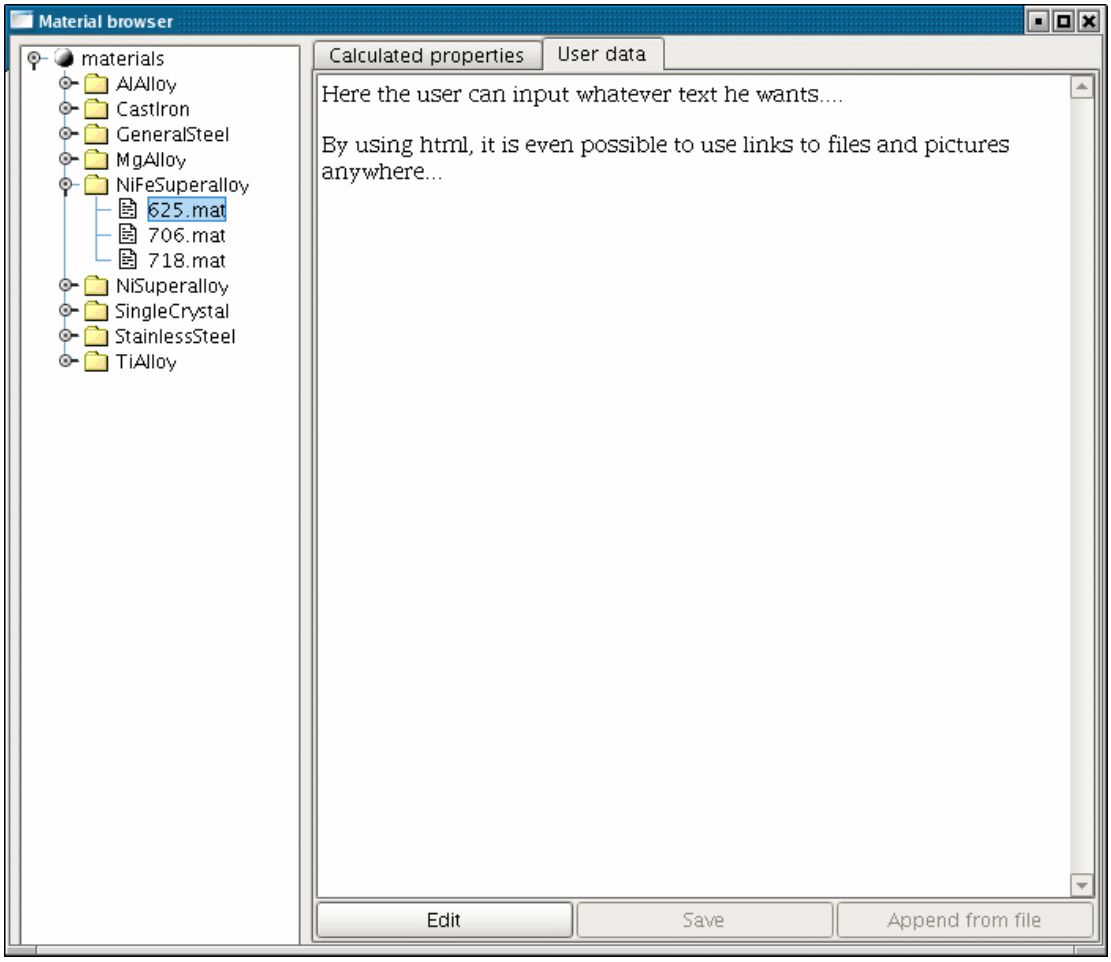
The top of the tree is the path to the file we are exploring. The tree has ramifications corresponding to properties, subproperties and datasets. To load or remove a dataset check the box corresponding to the dataset of interest and click the Load data or **Delete data** button.

The Buttons:

Load data Load the data associated to the selected datasets.
Load compo Transfer the current material file composition to the main window to be used as the work composition.
Delete data Delete from the material file the data associated to the selected datasets.
Change comment Modify the user comment associated to the current material file.
Move up Move a dataset or a property/subproperty up the tree.
Move down Move a dataset or a property/subproperty up down the tree.
Help Bring up this help window.
Exit Close the browser.



The User data tab:



It is possible possible for users to save their own data and comments alongside the data saved by JMatPro. To start the input of text, just press the **Edit** button to make the text panel editable and press the **Save** button to save your additions.

By pressing the **Append from file** button a file selection dialog will appear and the content selected file will be pasted at the end of the current text.

User's with knowledge of html can use html to provide basic formatting and styling of the text as well as links to pictures or files. However please be aware that the validity of the html text cannot be tested and we cannot help with html related issues.

2.3. common features

common features of graphs

All graph windows have common buttons and features.

Common buttons:

The following buttons are always present in the toolbar associated with graphs and behave in the same way.

- Set plotting preferences title and sizes/colors of lines and symbols.
- Toggle the appearance of the data grid. If the graph has got left and right vertical axis, this will in sequence attach the grid to the left than right axis then remove the grid.
- Set atomic or weight percentage for the composition.
- Set the temperature unit.
- Bring up the zoom box.
- Bring up this help window.
- Print graph.
- Save the current graph's data in a tab-delineated file for export to third party software. By default data will be saved in the JMatPro/export/data folder.
- Save the current graph as a picture in a graphics file. By default data will be saved in the JMatPro/export/pictures folder.
  At this time, snapshots can be exported to PNG, GIF, PS, EPS , PDF , JPEG and BMP file formats. The default is PNG (Portable Network Graphics) which although not yet widely known can be imported to documents in most common office applications and text processors.
- Save ALL the data associated to the calculation in a material file. This will enable you to regenerate the present window at a later date without performing the calculation again.
- Close the current window.

Common "hidden" features:

- **Drag zoom:** Holding the shift key down, clicking the left mouse button then dragging will define a zoom area. To reset the graph to full scale press "r" (reset) on the keyboard.

- **Point coordinates:** Clicking on a point in a graph will open an information window giving you the coordinates of the point

Saving data to material files.

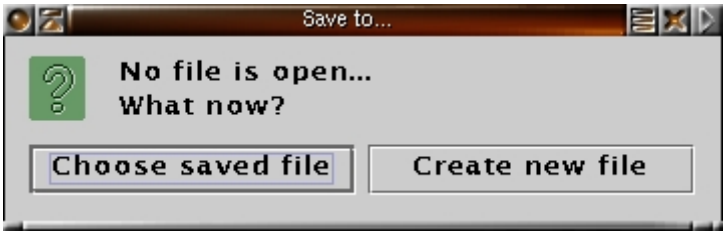
JMatPro features a built-in indexing system which keeps track of the saved data. Specifically, it associates all data with a material composition signature. This allows for instance JMatPro to find the right thermodynamic data when *i.e.* performing Strength and Hardness or general Physical properties calculations. Furthermore this allows quick location of appropriate existing material files when saving new data.

Saving data to a material file is usually triggered by pressing the **Save** button in data tables or the button in plots.

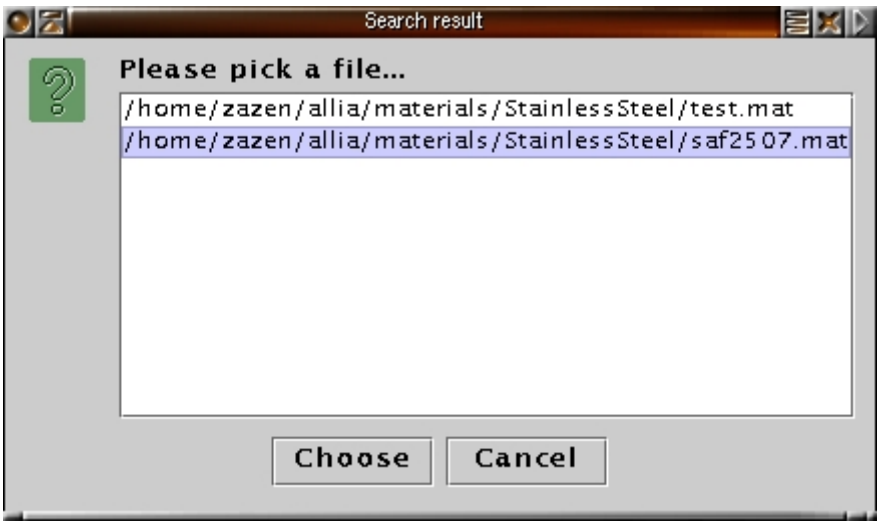
The program will look for existing material files with a signature matching the current composition.
Several cases may occur:

- **1. At least one matching file exists but no material file is open yet:**

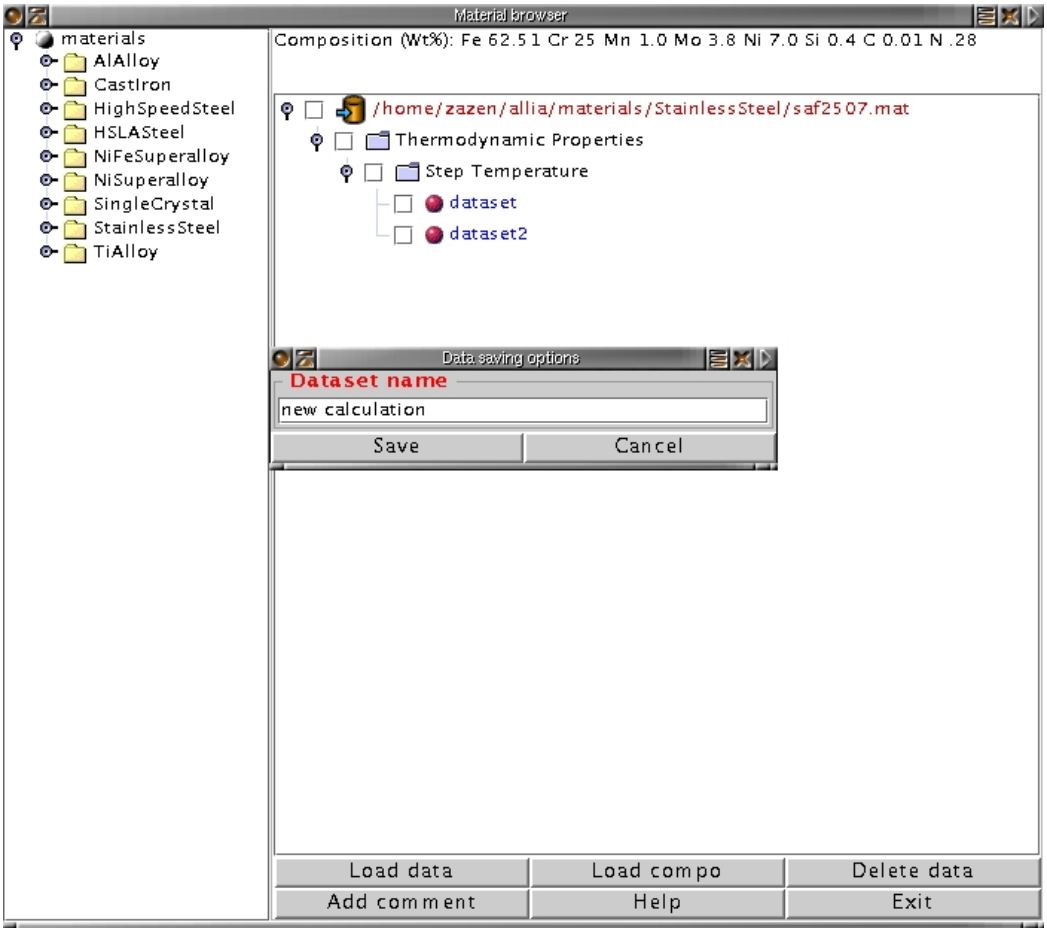
  In this case the program will ask the user if he wishes to use an existing file or create a new one:



  - If the user chooses to create a new file, we fall back on **case 3**.
  - If the user chooses to use an existing file, he is show the list of existing files and neeeds to select one:



Once the choice is made the appropriate file will be opened with its contents displayed in the materials browser and the user is prompted for a name for the dataset he is saving:



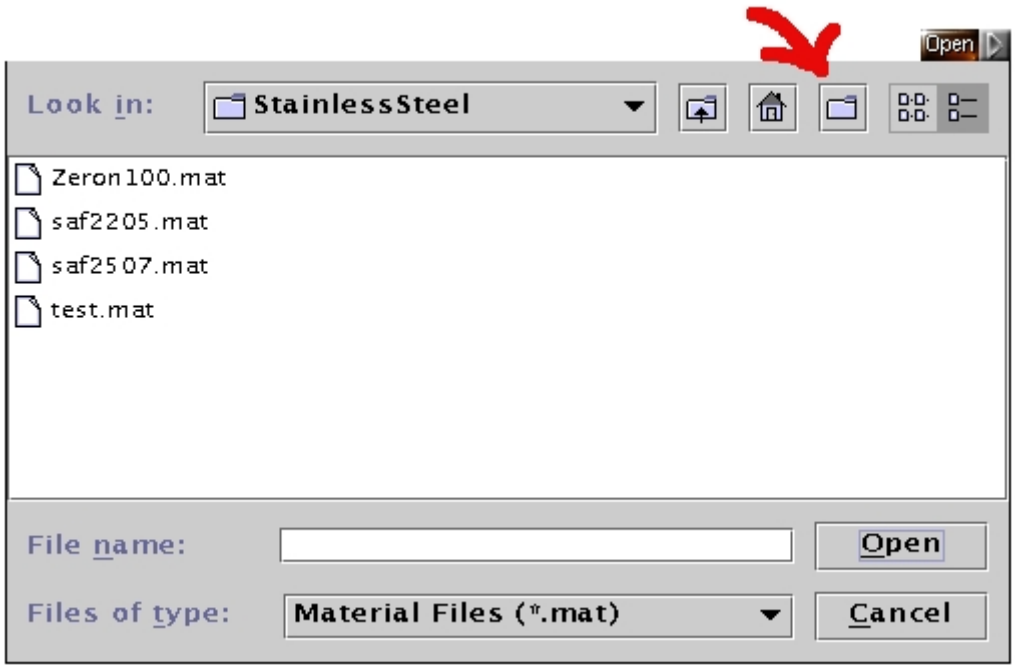
- **2. At least one matching file exists and a material file is open.**

  In this case the program will ask the user if he wishes to use the current file, another matching file or create a new one:

- **3. No matching file exists.**

  In this case the program will let the user know that no matching file exists and give the opportunity to create a new one:

If the creation of a new file has been chosen, a standard file creation dialog appears:



Please note that JMatPro supports subfolders in material folders so so you can create a subfolder (red arrow on the picture) in which to create the material file.

creating plot or table snapshots.

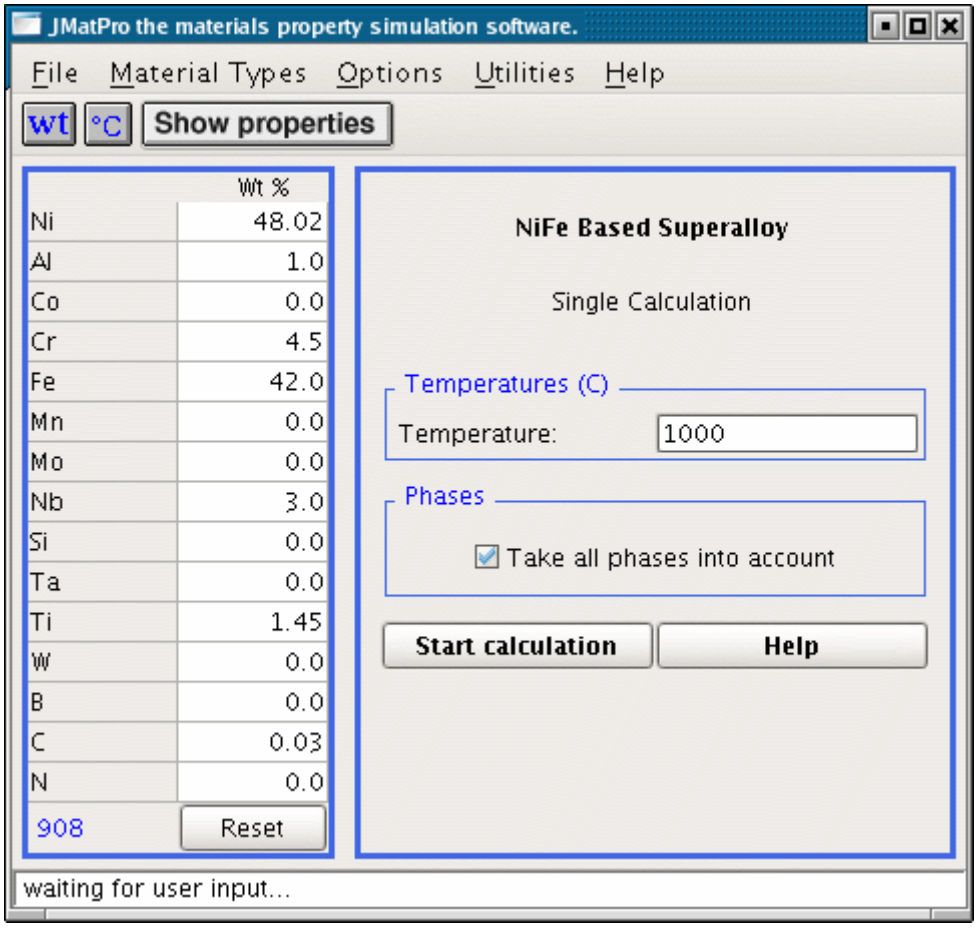
Creating snapshots of tables is triggered by pressing the **Save as picture** button in data tables or the button in plots.

By default data will be saved in the JMatPro/export/pictures folder. To change the name of the saved picture the user can edit the File name field. If another location is preferred the browse button will open a file dialog allowing easy navigation through the folder hierarchy on the user's computer.

Please note: Snapshots saved to PostScript, Encapsulated PostScript and files show glitches. Refer to this part of the FAQs to find out about alternatives.

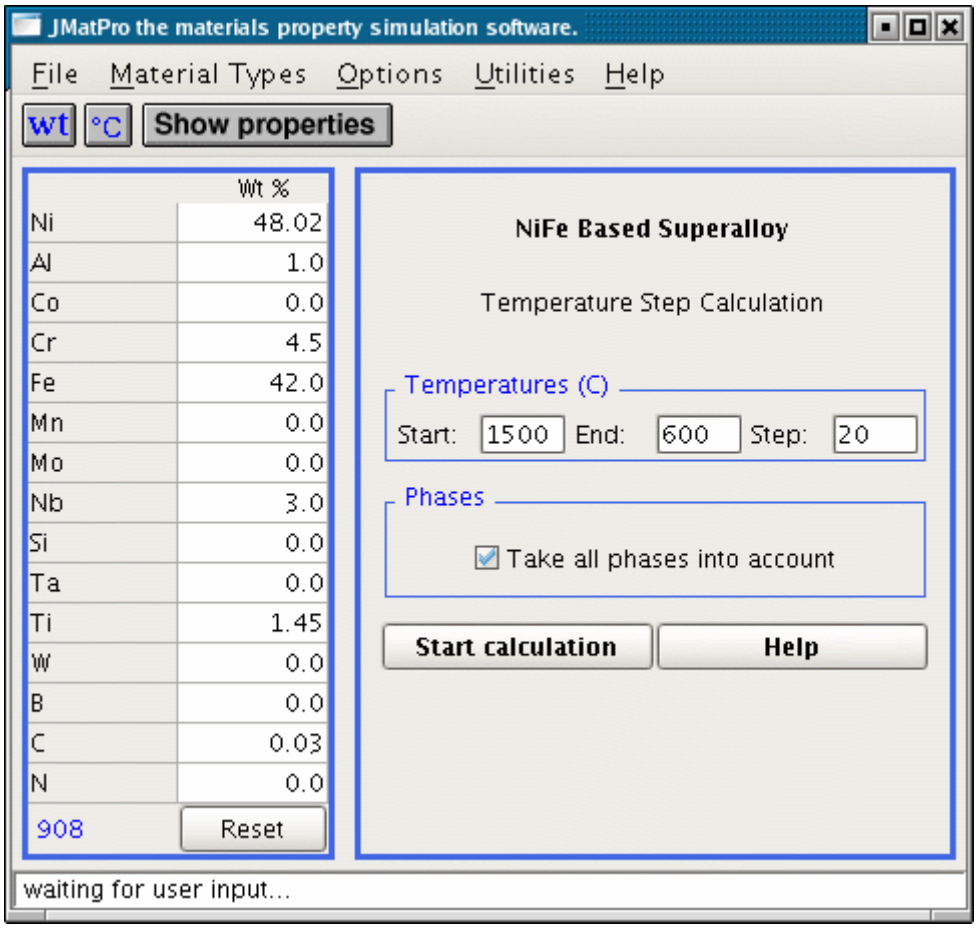
2.4. Thermodynamic calculations

2.4.1. single temperature thermodynamic calculation.



- Choose the temperature
- By default all available phases will be included in the calculation, should you want to suspend any phases, unselect the *Take all phases into account* checkbox and a phase selection dialog will appear.
- The **Start Calculation** button will launch the thermodynamic solver.

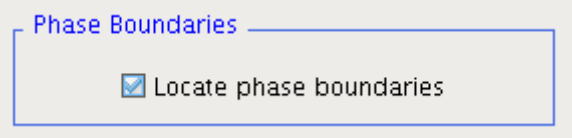
2.4.2. temperature stepping thermodynamic calculations.



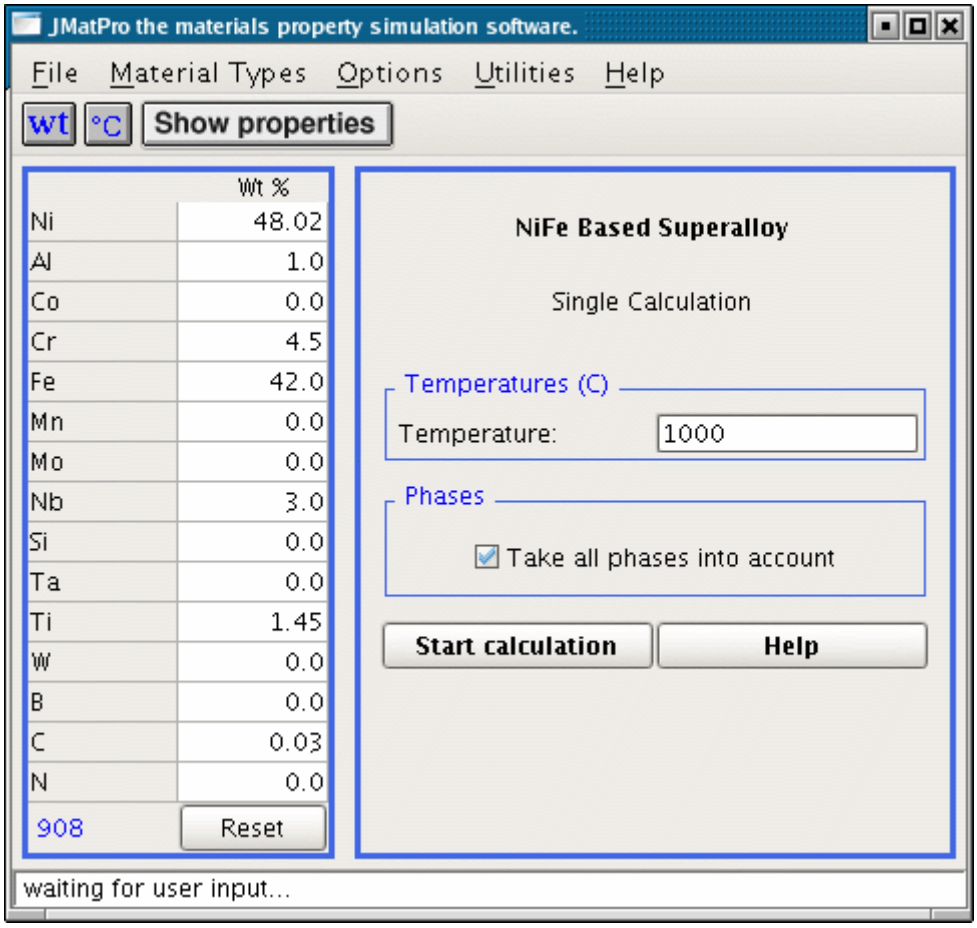
- Input start,end and step temperatures.
- By default all available phases will be included in the calculation, should you want to suspend any phases, unselect the *Take all phases into account* checkbox and a phase selection dialog will appear.
- The **Start Calculation** button will launch the calculation.

NOTES:

- The default temperatures and the direction (start at high or low temperature) are chosen in order to ensure the most efficient calculation in the majority of cases. Although the thermodynamic solver is very robust, it may be affected by the equilibrium at the starting point, the direction of the calculation or the step size. For complex calculations the user may wish to reverse the direction or change the temperature range and/or step size. Another possibility is to remove some phases from the calculation.
- If the thermodynamic solver finds a calculation difficult, in many cases it is because the exact location of a phase boundary is difficult. If this is not vital, it is possible to disable the phase boundary search. This can be done by going to the *Options-Show phase boundaries search control* menu item and checking it. This will add the following panel to the input window:



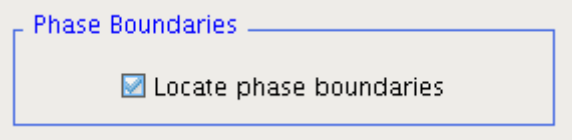
2.4.3. concentration stepping thermodynamic calculations.



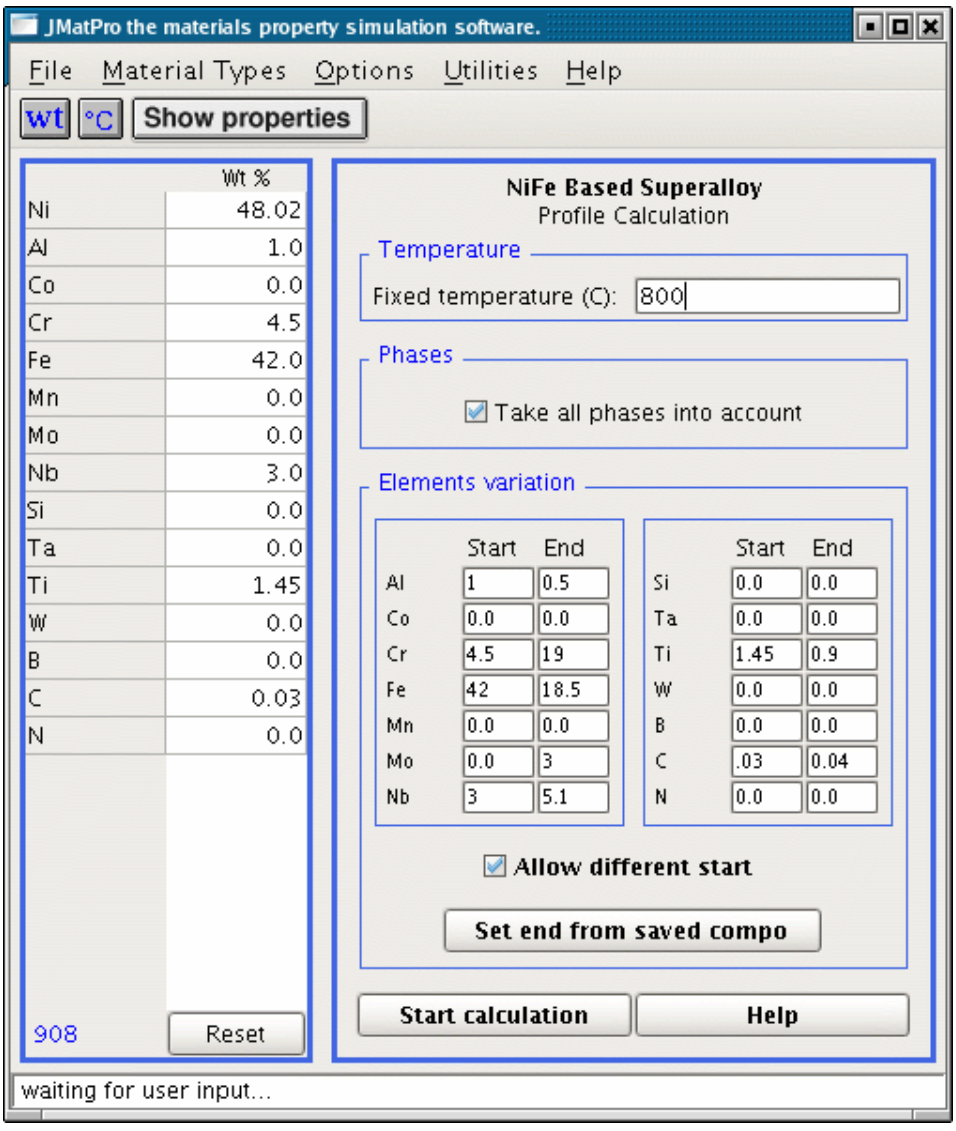
- The calculation is made at a fixed temperature which can be modified by the user.
- By default all available phases will be included in the calculation, should you want to suspend any phases, unselect the *Take all phases into account* checkbox and a phase selection dialog will appear.
- Two balancing modes are available:
  - One element: the balancing is done with only one element.
  - All elements: the balancing is done with all the elements in proportion of the initial composition.
- The varying element and the balance element can be modified.
- The composion start and end points as well as the step can be modified
- The **Start Calculation** button will launch the thermodynamic solver.

NOTE:

- If the thermodynamic solver finds a calculation difficult, in many cases it is because the exact location of a phase boundary is difficult. If this is not vital, it is possible to disable the phase boundary search. This can be done by going to the *Options-Show phase boundaries search control* menu item and checking it. This will add the following panel to the input window:



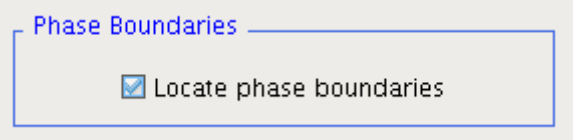
2.4.4. profile thermodynamic calculations.



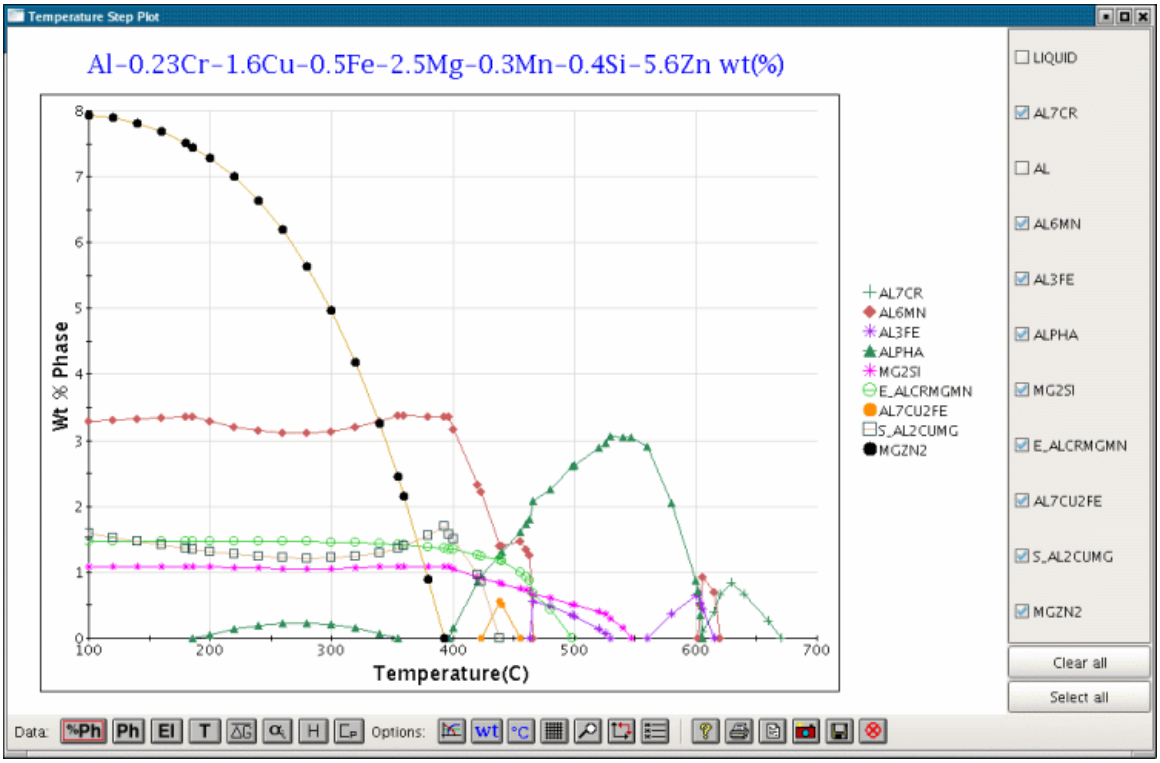
- The calculation is made at a fixed temperature which can be modified by the user.
- By default all available phases will be included in the calculation, should you want to suspend any phases, unselect the *Take all phases into account* checkbox and a phase selection dialog will appear.
- Input the end composition required. If this composition has been saved the **Set end from saved compo** button will allow to choose this composition.
- by default the start composition is the current one but it is possible to select any other one if **Allow different start** is selected
- The **Start Calculation** button will launch the thermodynamic solver.

NOTES

- For Al alloys, certain coatings may lead to phases not present in the thermodynamic database. Please check the phases list and if in doubt consult us.
- If the thermodynamic solver finds a calculation difficult, in many cases it is because the exact location of a phase boundary is difficult. If this is not vital, it is possible to disable the phase boundary search. This can be done by going to the *Options-Show phase boundaries search control* menu item and checking it. This will add the following panel to the input window:



2.4.5. phase equilibrium graphs



The Data Buttons:

- %Ph Plot phase distribution vs. temperature. This is the default display when the displayer is started in step mode.
- Ph Plot phase composition for a single phase.
- El Plot single element distribution among phases.
- T Plot single temperature analysis.
- ΔG Plot partial Gibbs energies.
- α_i Plot activities of the elements.
- H Plot Enthalpy vs. temperature.
- C_P Plot Heat capacity vs. temperature.

The Options Buttons:

- Toggle on and off the display of a grid on the graphs.
- Invert the axis orientation.
- Toggle the visibility of the side selector for phases/elements to be displayed.

Only active for single temperature analysis:

- Bring up a summary of data at the chosen temperature.
- Display phase distribution in respectively pie chart / multiple-bars / single bar chart form.
- Choose between 2D and 3D graphs.

The Elements/Phases Side Selector:

This selector gives you the choice of the elements or phases you want to appear on the current graph. Check/uncheck the various check boxes to keep or remove the phases or elements. The **Clear all** button will deselect everything. The **Select all** button will select everything. The selector can also be used very efficiently as a zoom tool: just deselect the major phases to show only the minor phases.

Should you wish not to display this selector, the buttons on the toolbar will toggle its appearance.

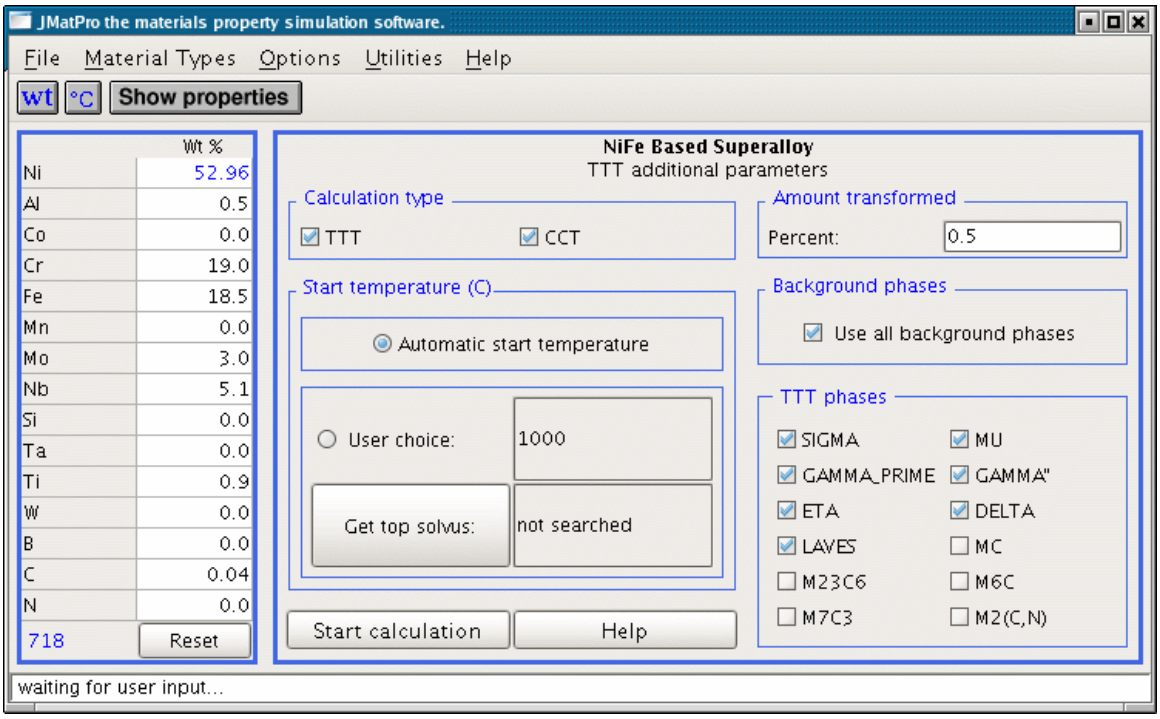
Other:

The other features and buttons are common to all graphs and are explained in the graphs page.

2.5. TTT/CCT calculations.

2.5.1. General TTT/CCT calculation

This page describes TTT/CCT calculations for Al, Ni and Ti alloys. Stainless steels are handled in a slightly different way explained here.



CCT calculation or start temperature input may not be always activated depending on the material type chosen.

By default the start temperature is calculated automatically. This temperature is calculated as being just above the temperature of the TTT phase with the highest solvus temperature. Alternatively the user can input their own value. For convenience, the "top" solvus can be calculated and displayed. Other input are the amount transformed and the background phases. The TTT phases are those for which curves will be calculated. Each can be deselected if required. The background phases are those that are included during the thermodynamic calculation to calculate driving forces.

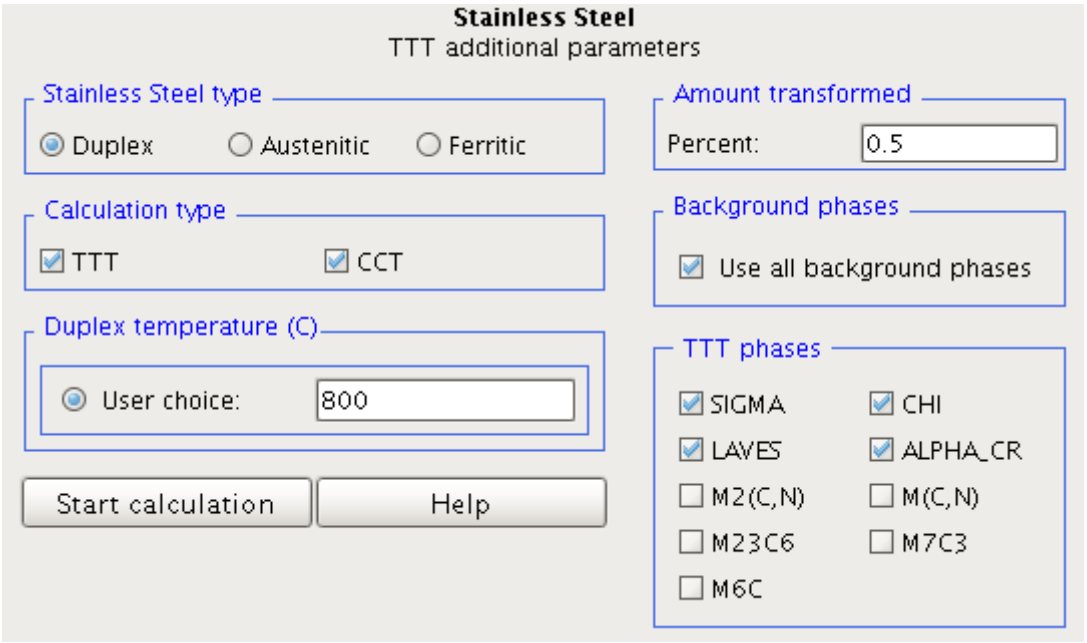
When carbides are included in the calculation, the start temperature can be different which as expected may lead to differences in the calculations.

2.5.2. Stainless Steel TTT/CCT calculations.

For Stainless Steel, the user is requested to choose between several sub-material types:

- Duplex Stainless Steel
- Ferritic Stainless Steel
- Austenitic Stainless Steel

Duplex Stainless Steel:



Duplex temperature:

- Input a temperature choice.

Amount transformed:

- Amount transformed: enter the transformation percentage required.

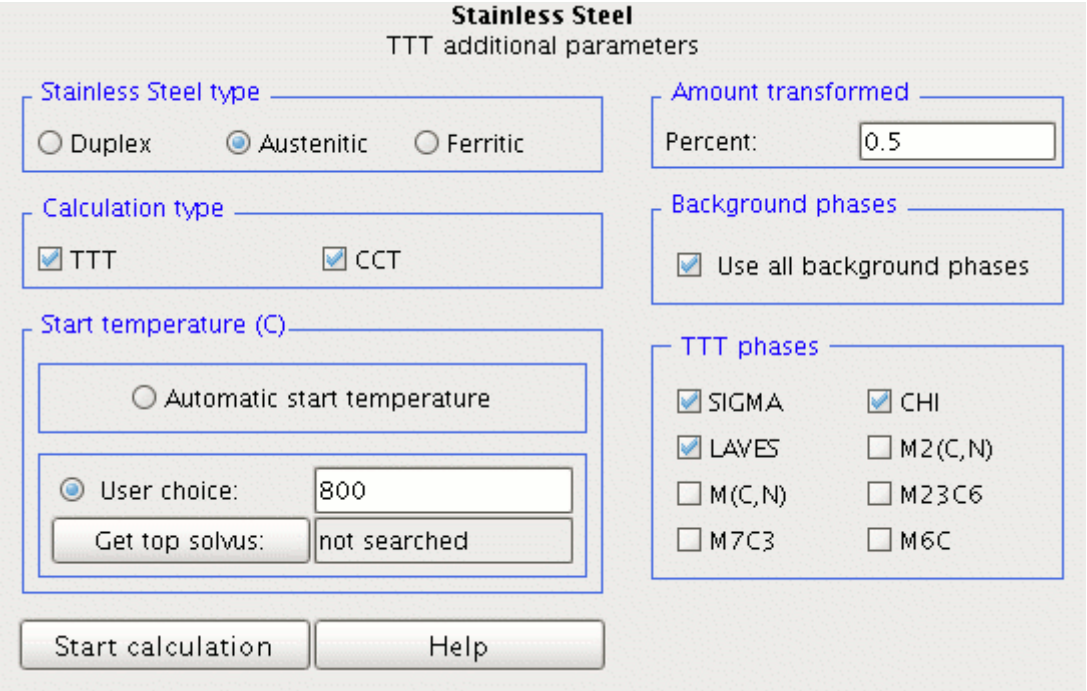
Background phases:

- This gives the user the ability to discard phases when performing thermodynamic calculations.

TTT phases:

- The calculation can be limited to certain phases transformations only. By default carbides are not selected

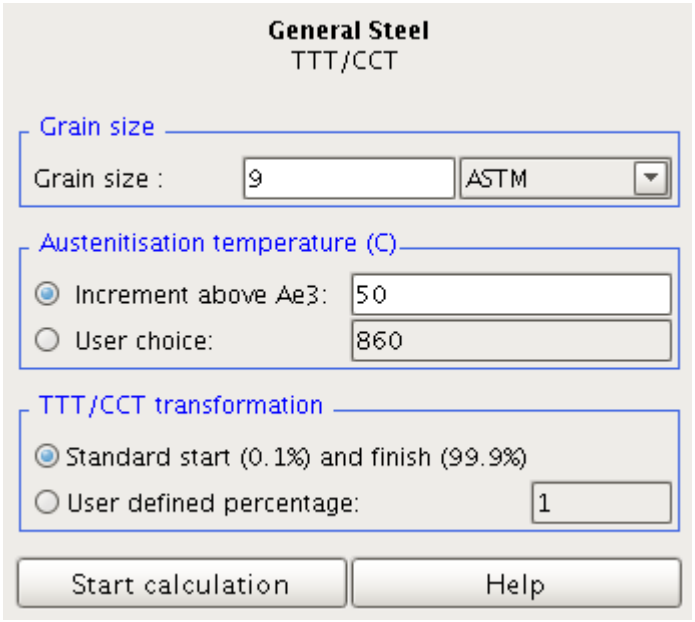
Ferritic or Austenitic Stainless Steel:



This is similar to the case of duplex stainless steels with the following addition:

- The start temperature for the calculation can be determined automatically or input by the user
- As a convenience, a *Get top solvus* button is provided. This will launch the thermodynamic solver to locate the highest transition point for the transformation phases and update the relevant field.

2.5.3. general steels TTT/CCT

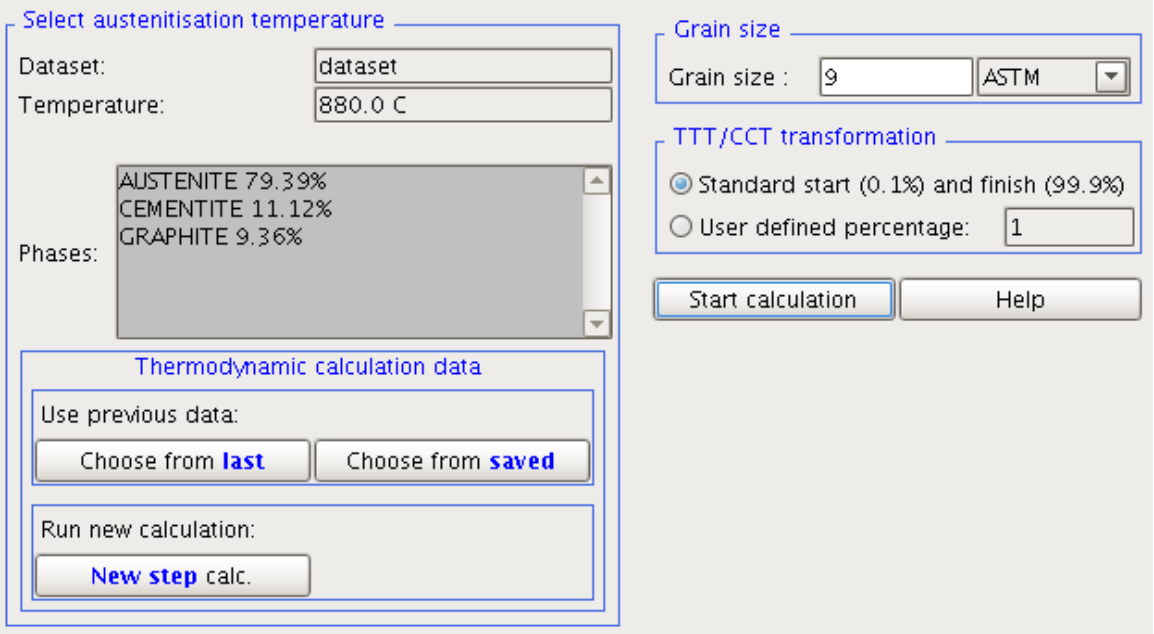


- Grain size: the grain size to be used (either ASTM or microns).
- Austenitisation temperature: you have two options:
    - Increment above Ae3: Let the JMatPro find the Ferrite transition in which case you are should enter the desired increment above the Ferrite transition temperature.
    - User choice: Specify a given temperature.
- Choose between a calculation for both standard start and finish transformations or for a single transformation. For a single transformation, please enter the transformation percentage required.

Press the **Start Calculation** button when you are done with the various selections.

2.5.4. TTT/CCT calculation: Cast Iron

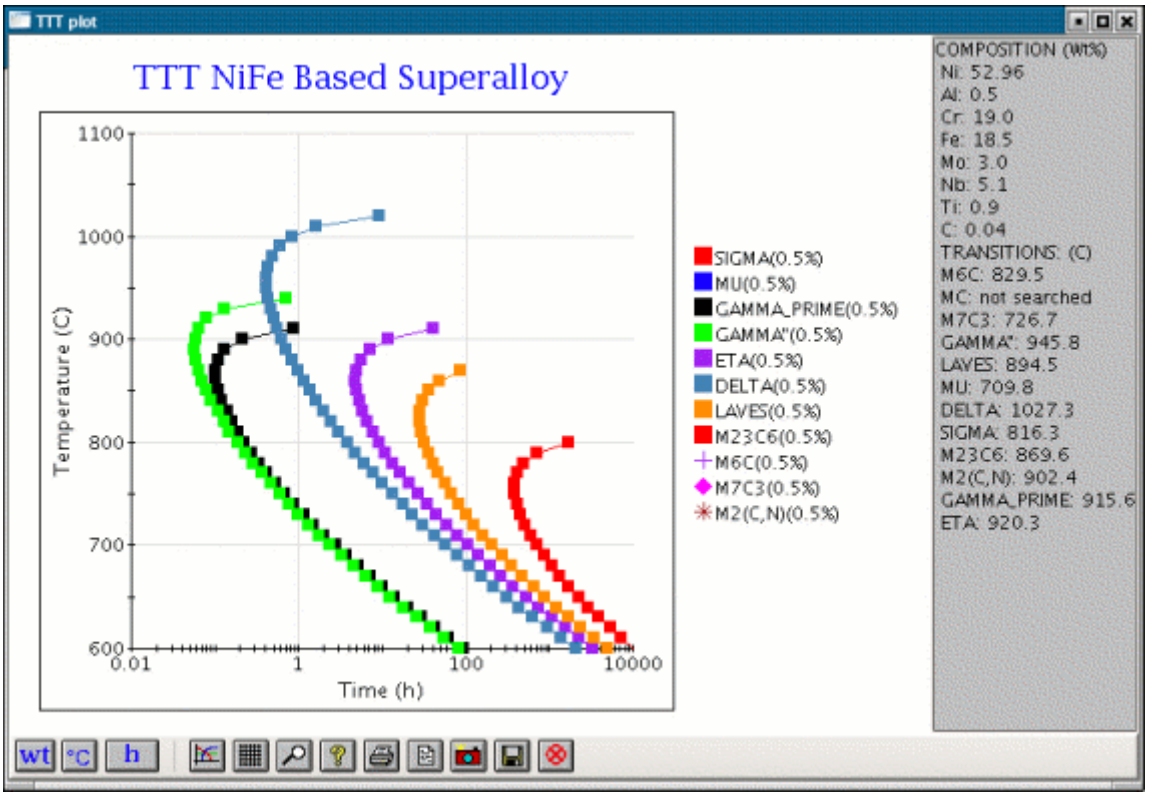
The austenitisation temperature needs first to be chosen as described here

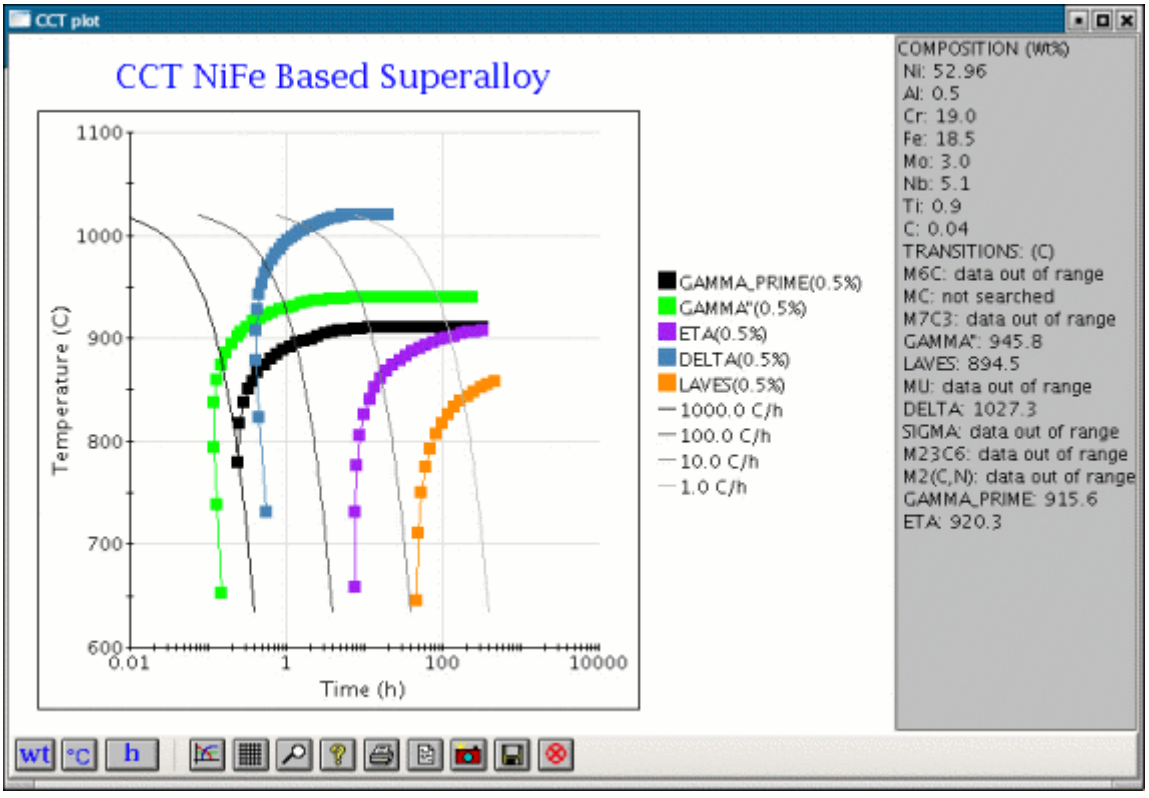


- Grain size: the grain size to be used (either ASTM or microns).
- Choose between a calculation for both standard start and finish transformations or for a single transformation. For a single transformation, please enter the transformation percentage required.

Press the **Start Calculation** button when you are done with the various selections.

2.5.5. TTT/CCT diagrams.





The Toolbar Buttons:

-

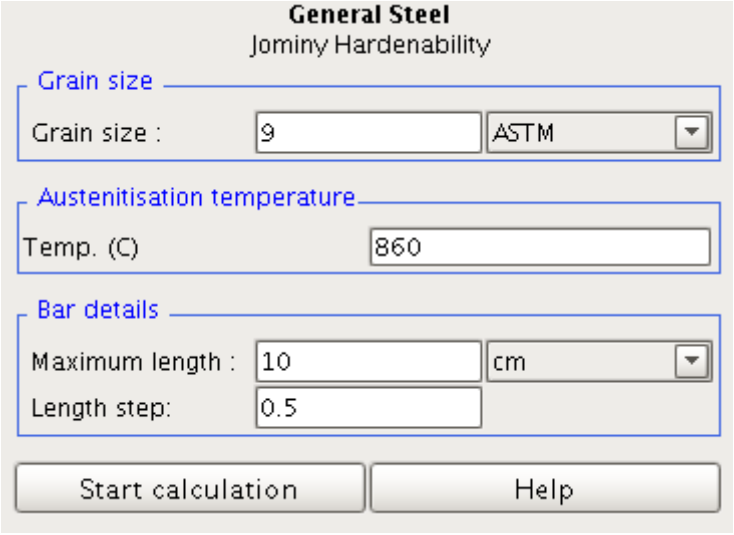
Set the time unit.

Other:

The other features and buttons are common to all graphs and are explained in the graphs page

2.6. Mechanical properties

2.6.1. general steels Jominy hardenability

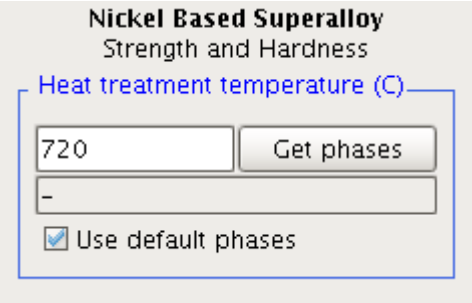


- Grain size: the grain size to be used (either ASTM or microns).
- Austenitisation temperature: specify a given temperature.
- Specify a maximum and step length.

Press the **Start Calculation** button when you are done with the various selections.

2.6.2. strength and hardness calculations.

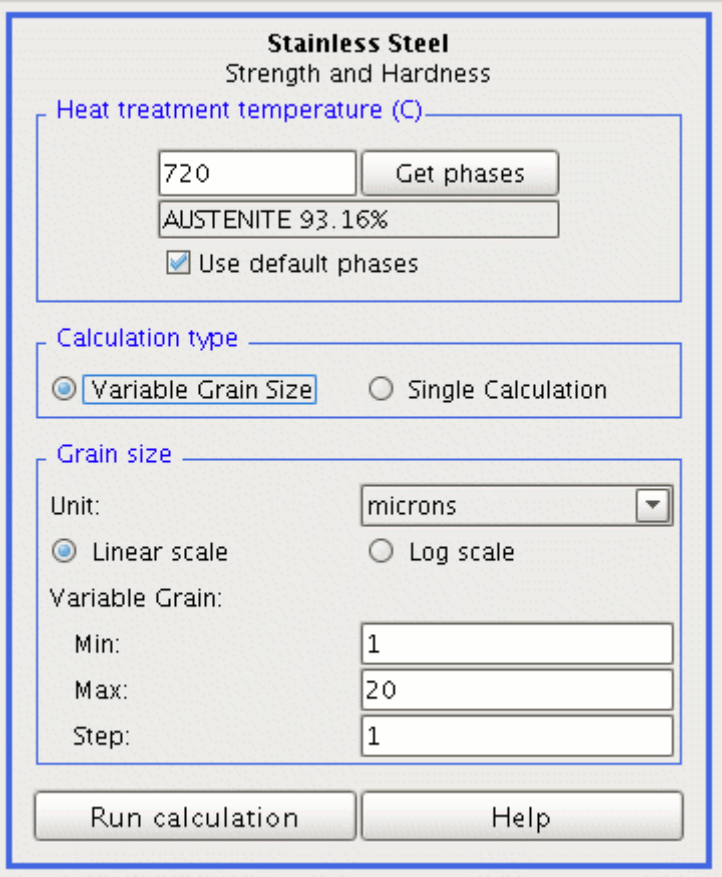
Heat treatment selection:



Input the required heat treatment temperature and press the **Get phases** button. This will calculate the phases present at this temperature. The phases included in the calculation can be controlled if the **Use default phases** option is not selected.

No precipitation hardening:

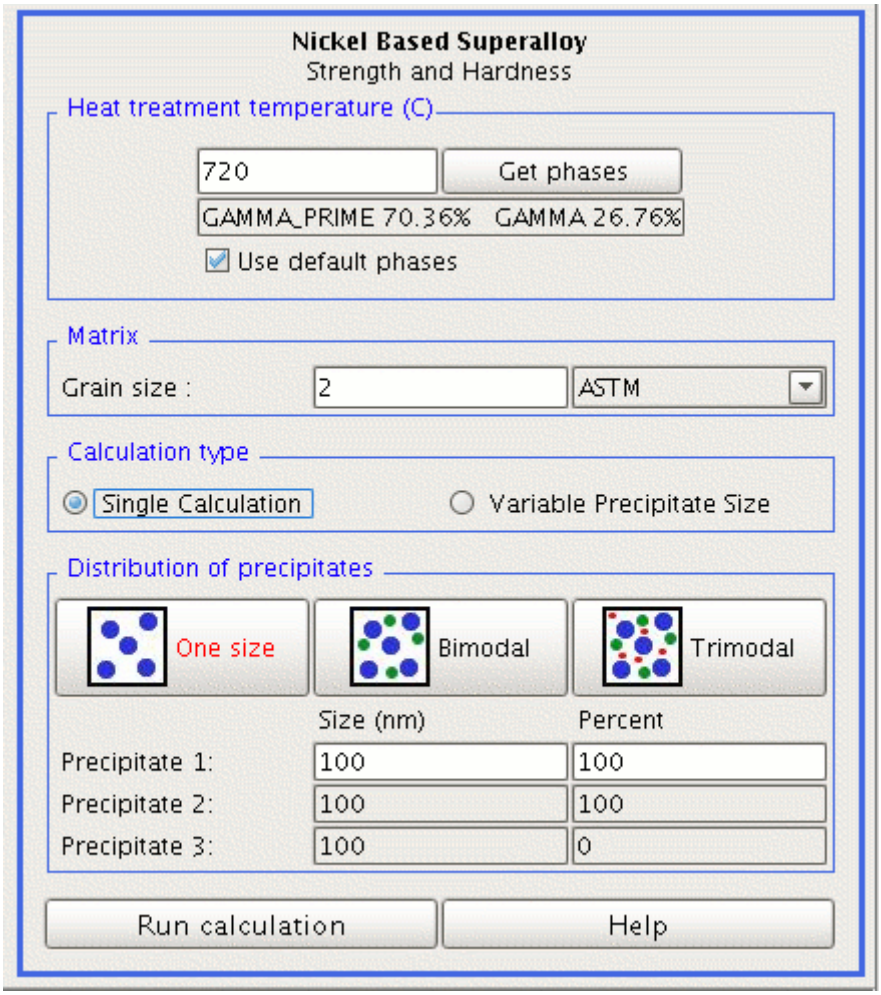
If there is no precipitate phase present at the chosen heat treatment temperature the input panel becomes:



- Choose between making a single calculation for a given grain size or a variable calculation with a range of sizes
- Choose between ASTM and micron for the grain size unit
- For variable calculation choose between a linear or a logarithmic range of sizes. For a linear range, input minimum,maximum and step values. For a logarithmic range input the the starting and end decades as well as the number of points per decade

One precipitate phase present:

When one precipitate phase is present and single calculation is selected, the input panel becomes:



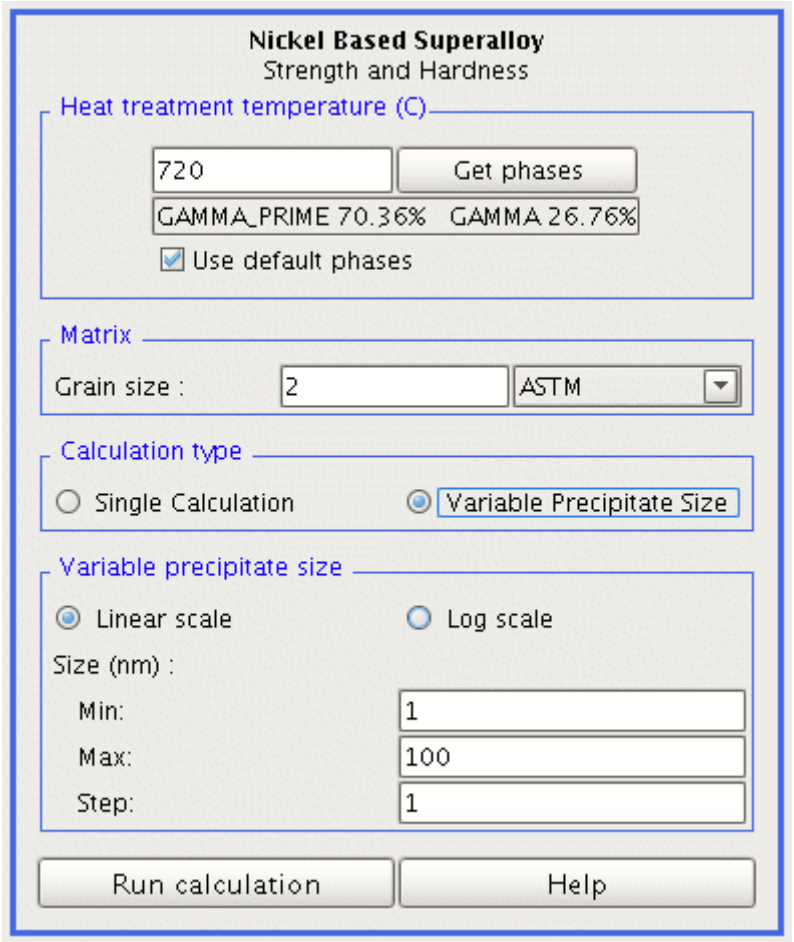
- By default **Single calculation** mode is selected.
- Select the unit for the grain size: ASTM or Micron.
- Imput the value of the matrix grain size.

- A precipitate distribution: select between uni- bi- and trimodal distributions and give size(s) and abundance(s).
  Please note that you will not get the same result with (for instance):
  - Unimodal distribution: 100% of size S
  - Bimodal distribution: 35% of size S and 65% of size S

  We summate the strengthening contribution of each size distribution. However, in the extreme where the sizes are the same the addition gives a value greater than a single distribution of that size. This is due to non-linear effects in the strength equations. Our testing shows the additivity rule works well when there is a distinct size difference (i.e. factor of 2 or more). When sizes are closer an average size would be better.

- To launch a calculation press the **Run calculation** button.

If the **Variable precipitate size** mode is selected. The input panel becomes:



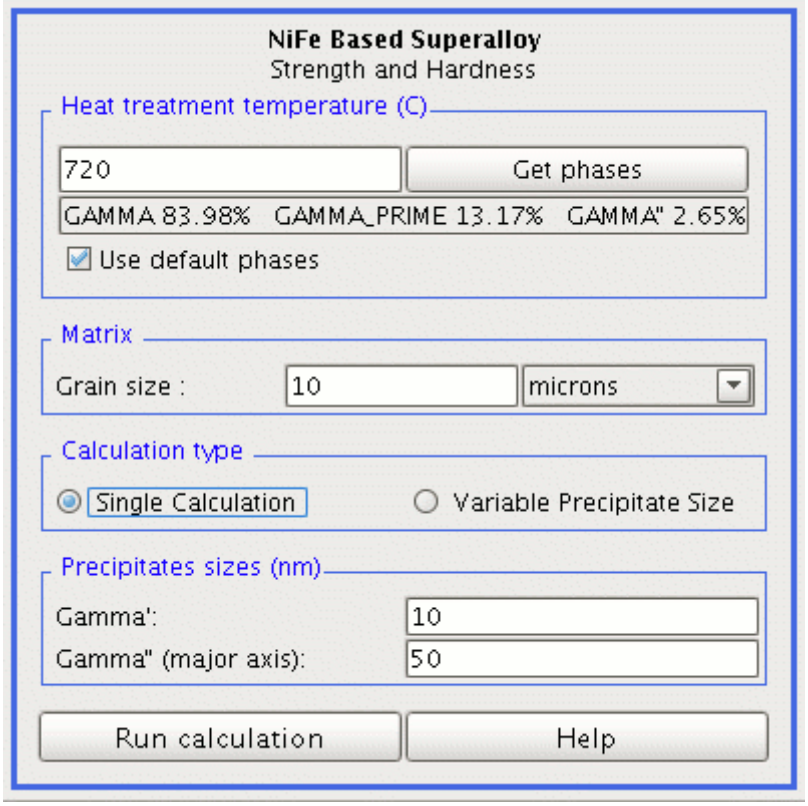
In this case the input required is:

- A matrix grain size (unit either ASTM or micron)

- A linear or a logarithmic range of sizes. For a linear range, input minimum,maximum and step values. For a logarithmic range input the the starting and end decades as well as the number of points per decade

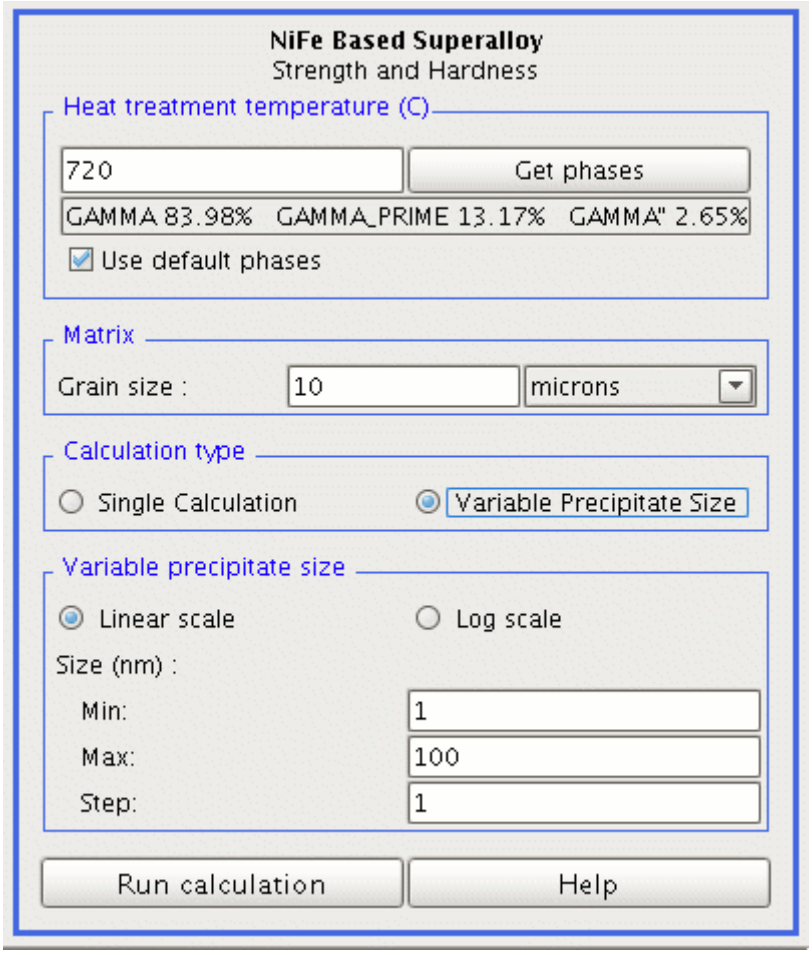
Two precipitate phases present:

When two precipitate phases are present (Gamma' and Gamma" in Ni based alloys) at the chosen heat treatment temperature, the input panel becomes:



- By default **Single calculation** mode is selected.
- A matrix grain size (unit either ASTM or micron)
- A particle size for Gamma' and Gamma"

If the **Variable precipitate size** mode is selected. The input panel becomes:



In this case the additional inputs required are:

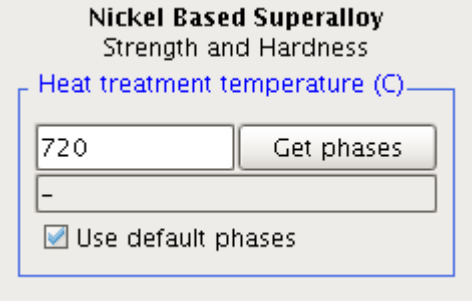
- A matrix grain size (unit either ASTM or micron)
- A linear or a logarithmic range of sizes. For a linear range, input minimum,maximum and step values. For a logarithmic range input the the starting and end decades as well as the number of points per decade

2.6.3. high temperature strength calculations.

NOTES

For Ti alloys, the calculation is for the time being limited to medium temperatures.

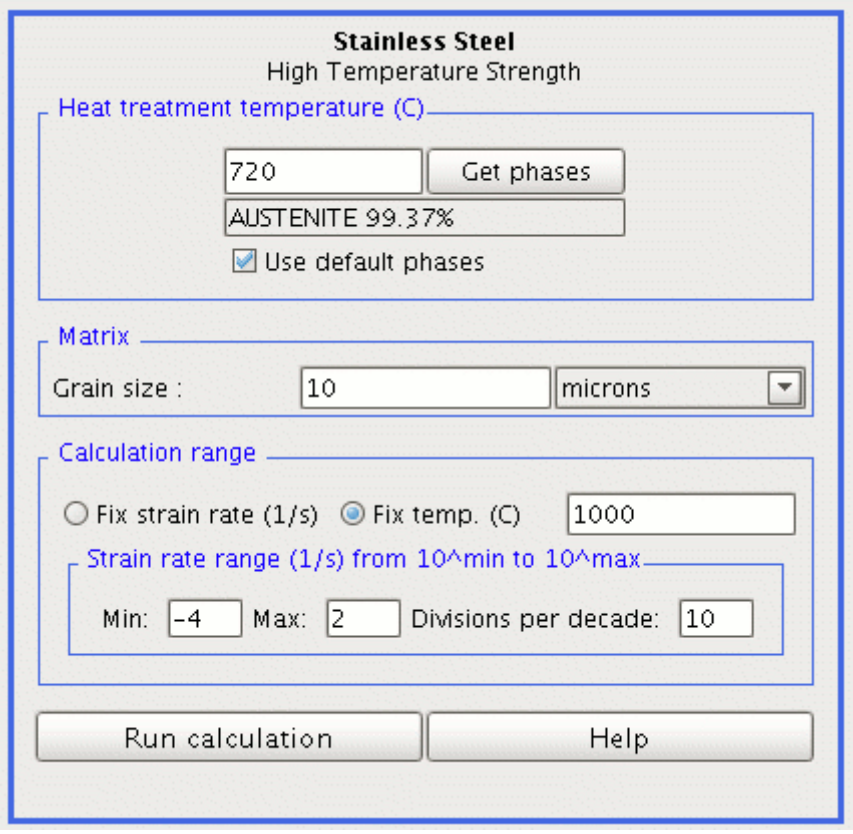
Heat treatment selection:



Input the required heat treatment temperature and press the **Get phases** button. This will calculate the phases present at this temperature. The phases included in the calculation can be controlled if the **Use default phases** option is not selected.

1. No precipitation hardening:

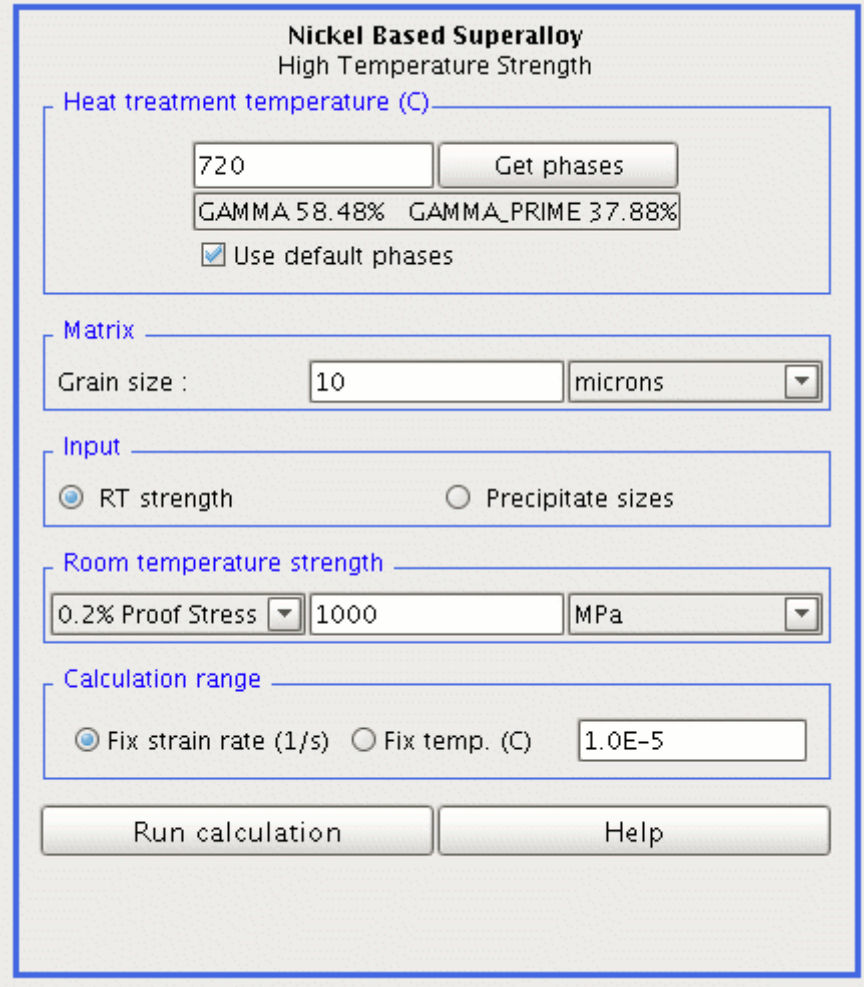
If there is no precipitate phase present at the chosen heat treatment temperature the input panel becomes:



- Input a matrix grain size choosing between ASTM and micron for the grain size unit.
- Select between variable temperature or variable strain rate calculation and input the value of the fixed temperature/strain rate. If variable strain rate is chosen, input on a logarithmic scale of minimum and maximum decade and number of values per decade are required.

One precipitate phase present:

When one precipitate phase is present and single calculation is selected, the input panel becomes:



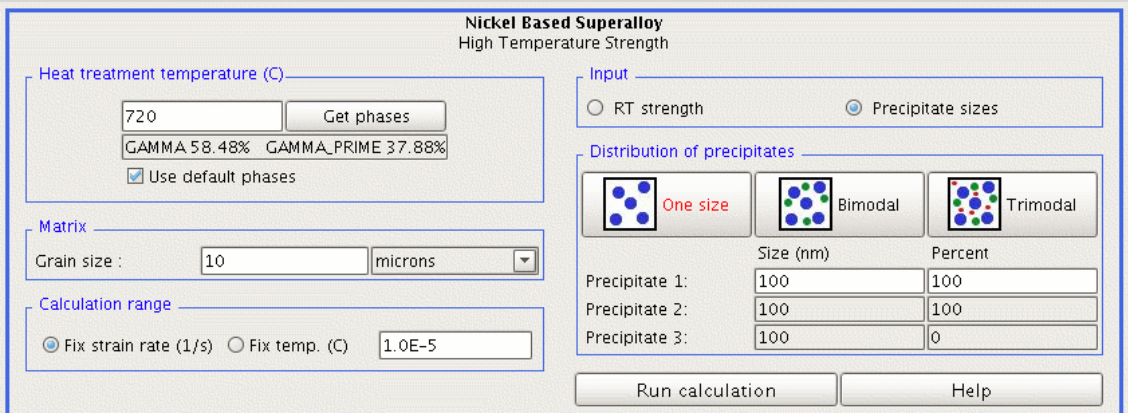
- Input a matrix grain size choosing between ASTM and micron for the grain size unit.
- Select between variable temperature or variable strain rate calculation and input the value of the fixed temperature/strain rate. If variable strain rate is chosen input of minimum, maximum and step values are required.

Additional input about the precipate phase is required, this can either be the room temperature proof stress/ultimate tensile stress, hardness or particle size.

Input or RT stress/hardness:

- Select the available data type and unit and input the value.
- Please note that the particle size is calculated from room temperature strength assuming a standard strain rate of 0.02/min. As such in the proof stress vs temperature graph the value at room temperature will be renormalised to take into account a different strain rate.

Input of particle size(s):



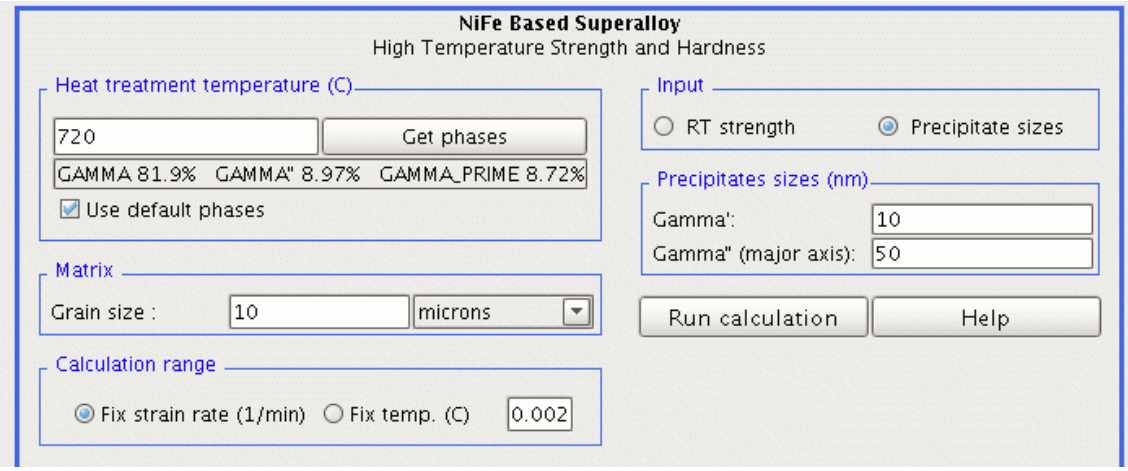
- Precipitate distribution: select between uni- bi- and trimodal distributions and give size(s) and abundance(s).
  Please note that you will not get the same result with (for instance):
  - Unimodal distribution: 100% of size S
  - Bimodal distribution: 35% of size S and 65% of size S

  We summate the strengthening contribution of each size distribution. However, in the extreme where the sizes are the same the addition gives a value greater than a single distribution of that size. This is due to non-linear effects in the strength equations. Our testing shows the additivity rule works well when there is a distinct size difference (i.e. factor of 2 or more). When sizes are closer an average size would be better.

Two precipitate phases present:

When two precipitate phases are present (Gamma' and Gamma" in Ni based alloys) at

the chosen heat treatment temperature. It is very similar to the case of one precipitate. The only difference is that the precipitate size input panel is simpler.

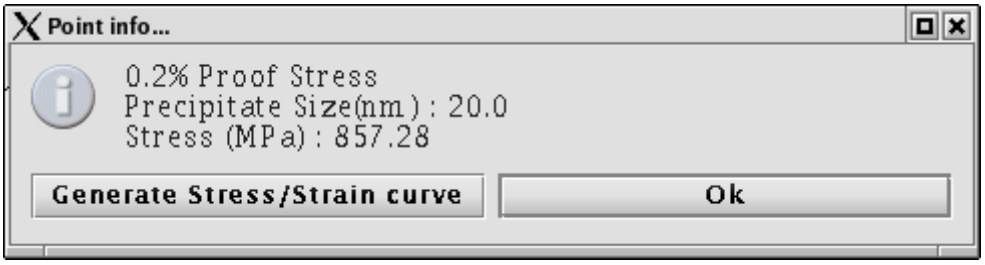


2.6.4. stress and hardness plots.

The Toolbar Buttons:

- MPa ksi Toggle the stress unit between MPa and ksi.
- VPN HRC Toggle the hardness unit between VPN and Rockwell C.
- ASTM µm Toggle the grain size unit between ASTM and micron (if relevant).
- lin log Toggle the grain-size axis scale between logarithmic and linear.

Generate stress-strain curves:



In the case of stress and hardness plots, clicking on a point not only opens a window

giving the point coordinates but gives you the opportunity to generate a stress-strain curves using the data at this point. Simply press the relevant button and the stress-strain curve will be calculated automatically.

Other:

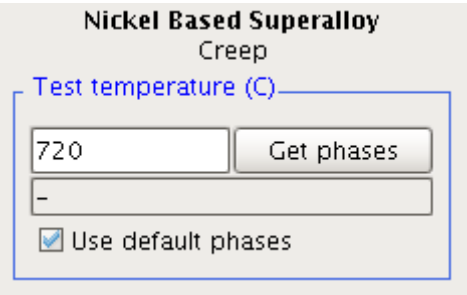
The other features and buttons are common to all graphs and are explained in the graphs page.

2.6.5. creep calculations.

IMPORTANT

- For single crystal, creep calculations are valid for alloys which growth direction is along the [001] direction. This covers alloys in CMSX, Mar and Rene families.

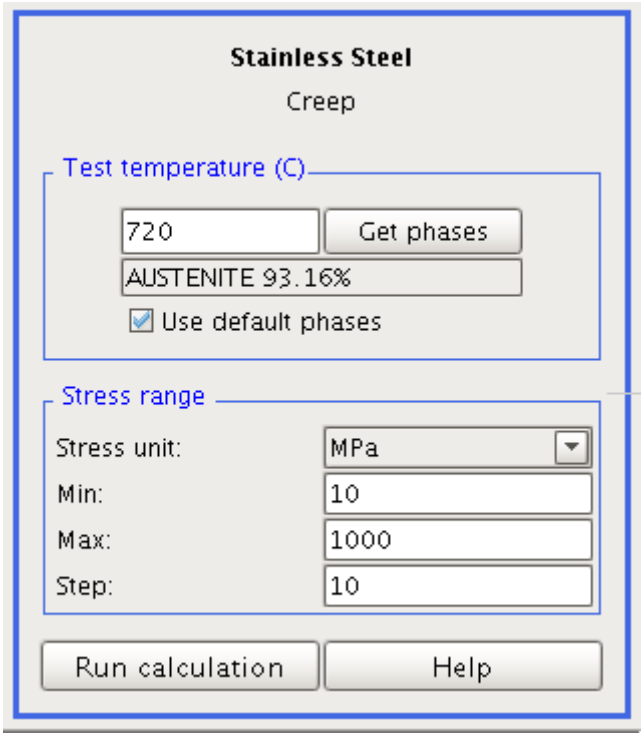
Heat treatment selection:



Input the required heat treatment temperature and press the **Get phases** button. This will calculate the phases present at this temperature. The phases included in the calculation can be controlled if the **Use default phases** option is not selected.

No precipitation hardening:

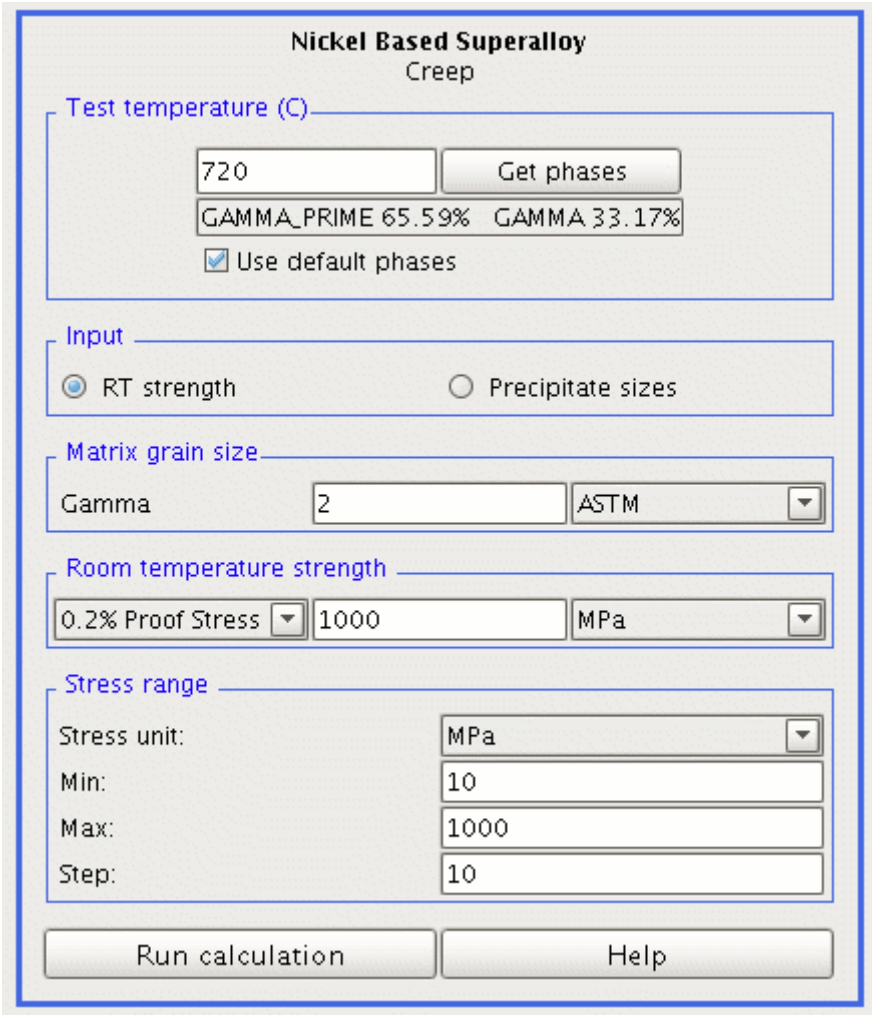
If there is no precipitate phase present at the chosen heat treatment temperature the input panel becomes:



- Select the stress unit and the input the range requested.

One precipitate phase present:

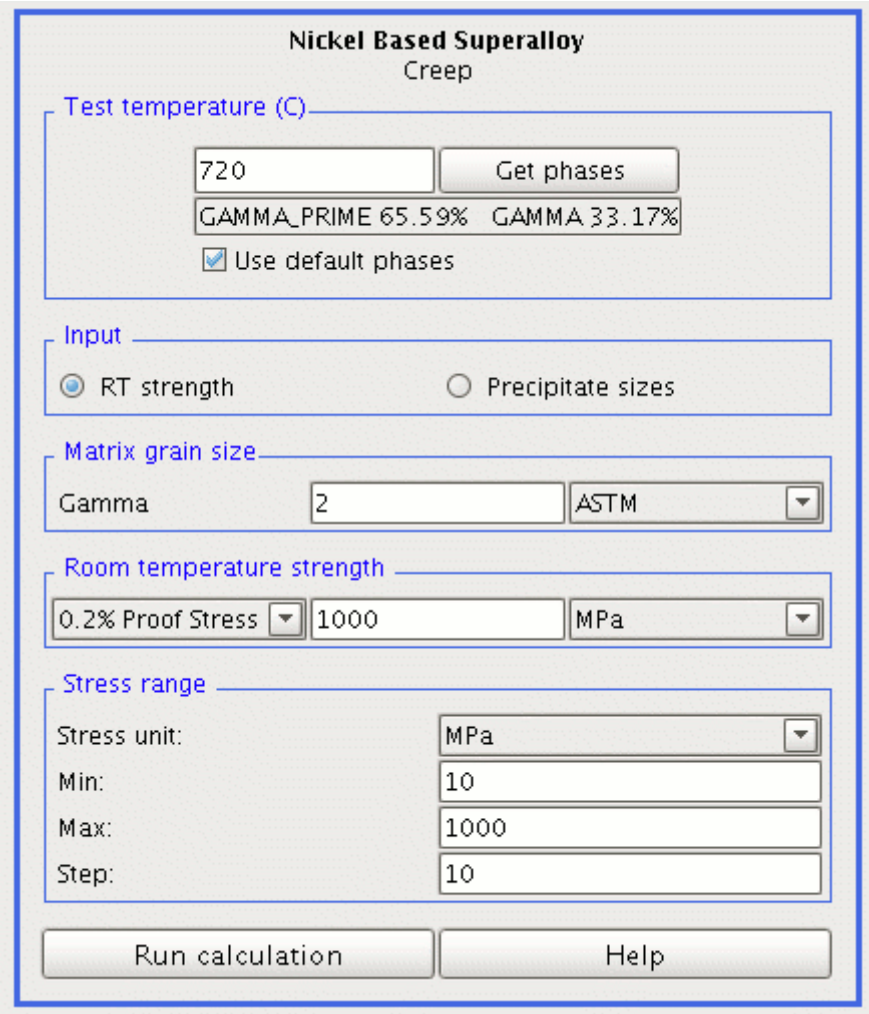
When one precipitate phase is present and single calculation is selected, the input panel becomes:



- Input a matrix grain size choosing between ASTM and micron for the grain size unit.
- Select the stress unit and the input the range requested.

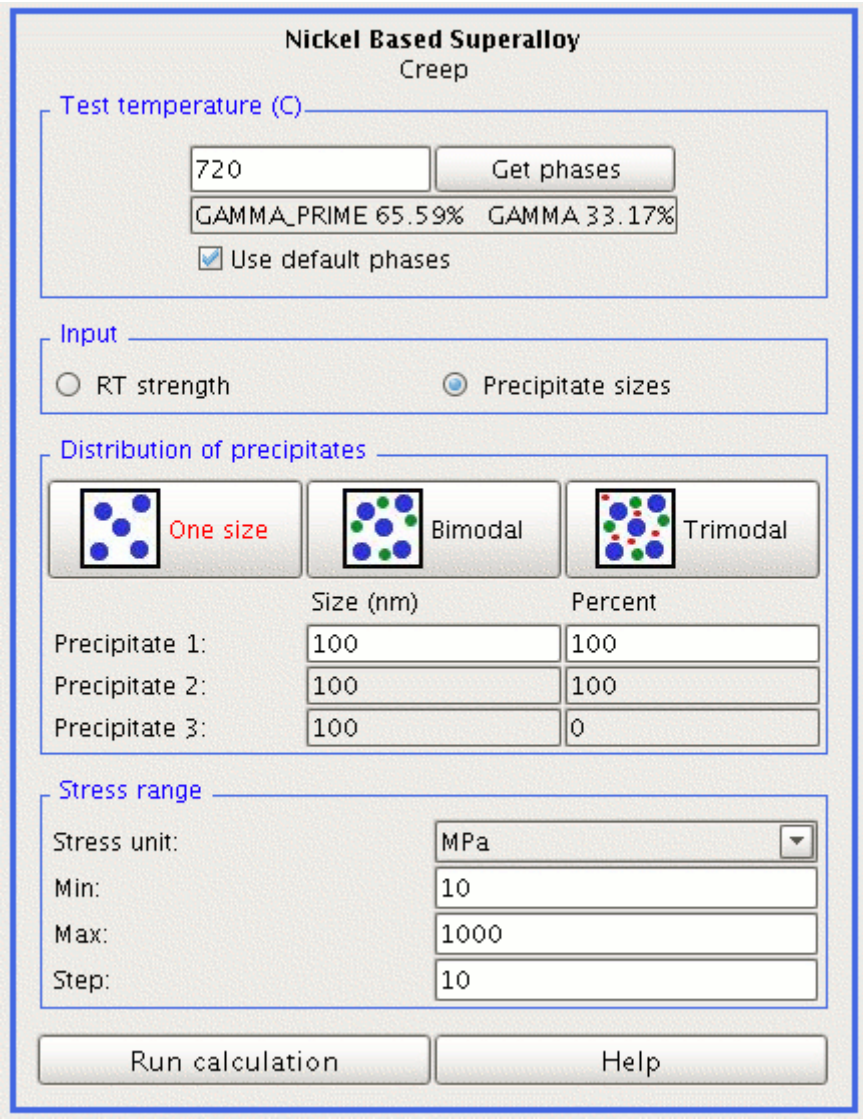
Additional input about the precipate phase is required, this can either be the room temperature proof stress/ultimate tensile stress, hardness or particle size.

Input or RT stress/hardness:



- Select the available data type and unit and input the value.

Input of particle size(s):

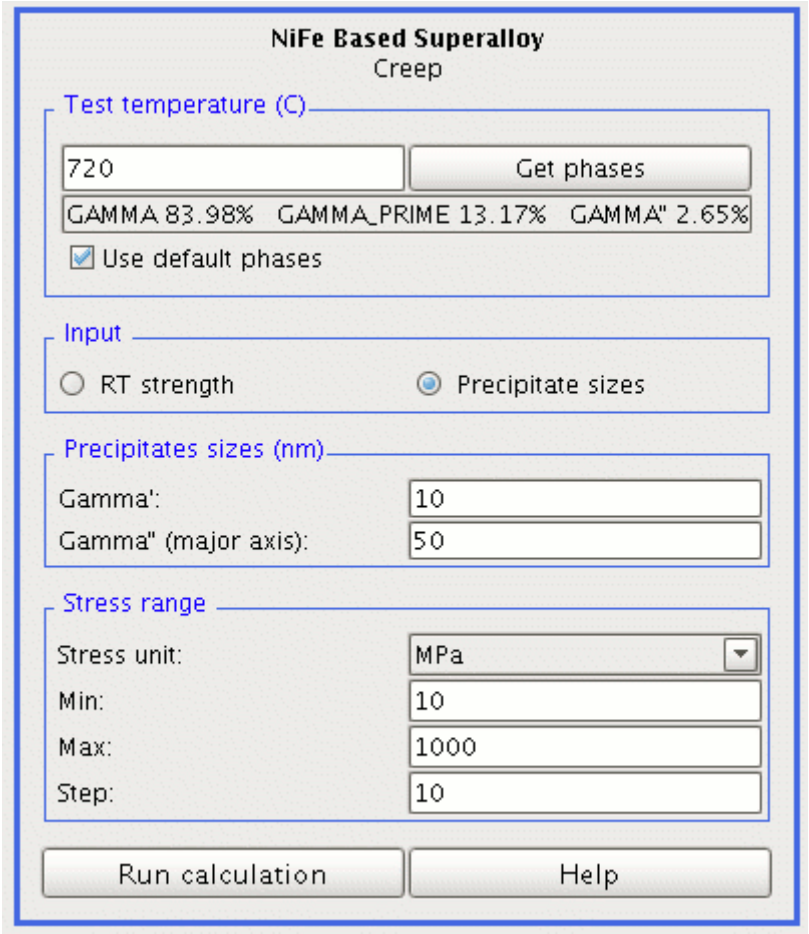


- Precipitate distribution: select between uni- bi- and trimodal distributions and give size(s) and abundance(s).
  Please note that you will not get the same result with (for instance):
  - Unimodal distribution: 100% of size S
  - Bimodal distribution: 35% of size S and 65% of size S

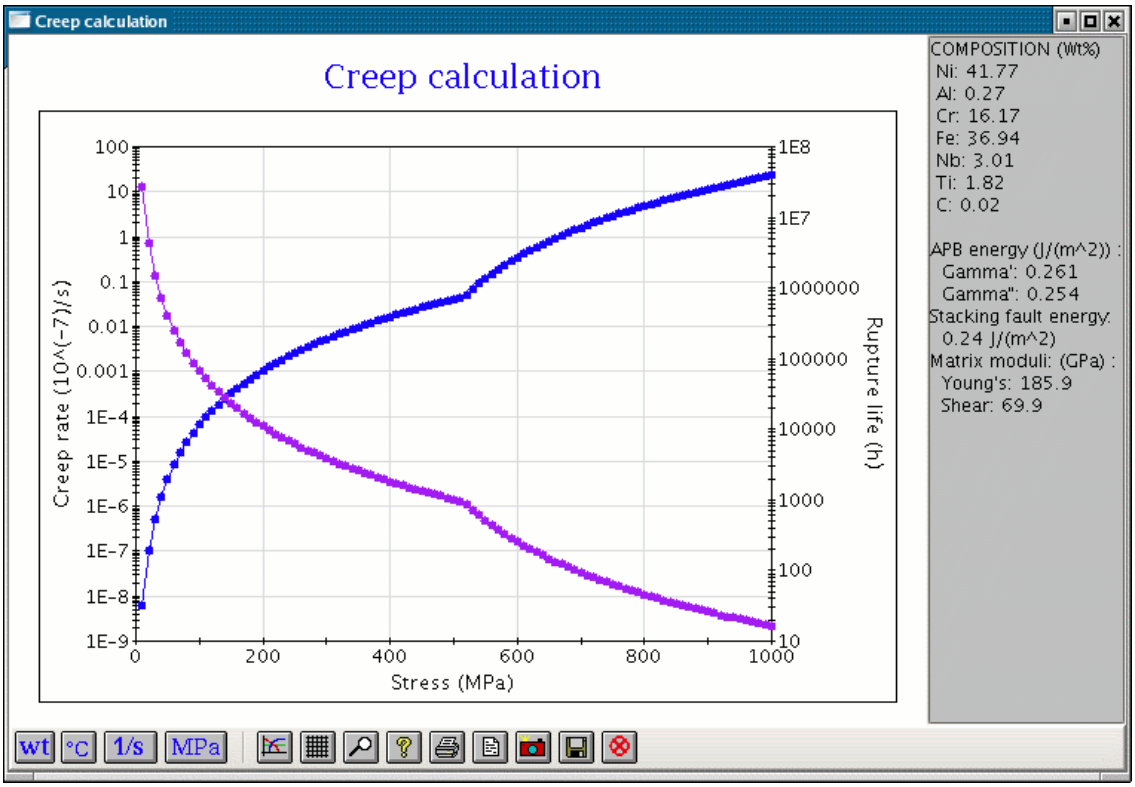
  We summate the strengthening contribution of each size distribution. However, in the extreme where the sizes are the same the addition gives a value greater than a single distribution of that size. This is due to non-linear effects in the strength equations. Our testing shows the additivity rule works well when there is a distinct size difference (i.e. factor of 2 or more). When sizes are closer an average size would be better.

Two precipitate phases present:

When two precipitate phases are present (Gamma' and Gamma" in Ni based alloys) at the chosen heat treatment temperature. It is very similar to the case of one precipitate. The only difference is taht the precipitate size input panel is simpler.



2.6.6. creep plots.



The Toolbar Buttons:

- MPa ksi Toggle the stress unit between MPa and ksi.
- 1/s 1/h Set the time unit for the creep rate.
- lin log Toggle the time axis scale between logarithmic and linear.

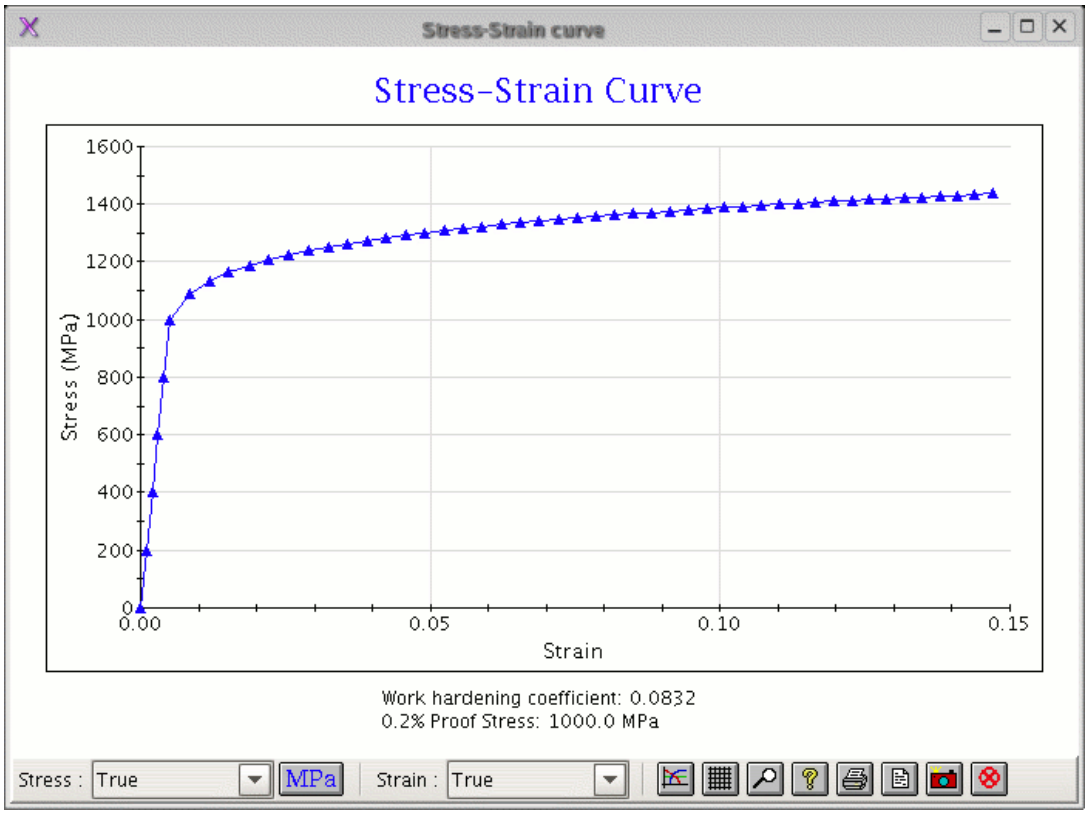
Other:

The other features and buttons are common to all graphs and are explained in the graphs page.

Note:

When gamma' or gamma" is present an inflexion point in the curve may be seen. This is due to a transition that occurs above a characteristic stress level, which is related to the back stress arising from the hardening effect of these phases. A more detailed explanation can be found here.

2.6.7. stress-strain curves.



Creation:

Stress-strain curves are generated "on the fly" from stress and hardness plots.

The toolbar Buttons:

- Two choice boxes allow to toggle between Engineering and True stress or strain.
- MPa ksi Toggle the stress unit between MPa and ksi.

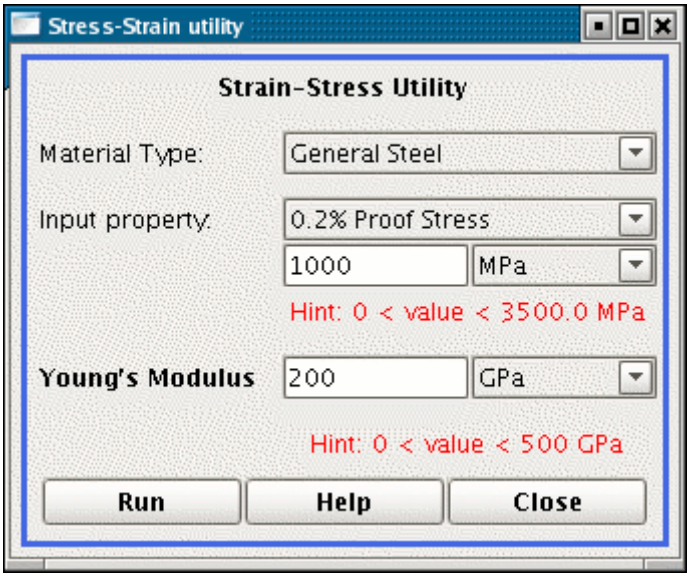
Other:

The other features and buttons are common to all graphs and are explained in the graphs page.

Note:

Please note that since stress-strain curves are generated "on the fly" from strength-hardness curves, it is not possible to save them in material files.

2.6.8. Stress-strain curves utility.



- Select the material type to use
- Select the know property for which a value is known: 0.2% proof stress, tensile stress or hardness
- Input a value for the stress/hardness
- Input a value for Young's modulus
- Press the *Run* button to calculate the stress-strain curve

Note: This is the stress strain utility which requires input values to be given. An alternative way of generating stress-strain curves is to click on any point in a stress or hardness plot.

2.7. Thermo-Physical and Physical properties

2.7.1. Choice of physical properties calculation

Thermo-physical and physical properties in JMatPro can be calculated in different ways. It is important to understand the purpose of each calculation in order to use the most suitable to your application. The various calculations are:

- General calculation
- Dynamic calculation

- Extended general calculation
- Solidification properties

General calculation

General is the physical and thermo-physical properties calculations which was already present in version 1 of JMatPro. It has been kept and improved in case you find it useful, please let us know if you are still using it. It has been superseded by the extended general properties, which is more powerful and generally recommended.

In the general mode the user chooses a heat treatment temperature, which defines the phase amounts, and physical properties are calculated at various temperatures below the heat treatment temperature keeping the phase distribution frozen. The results are displayed in a table and no details on the contribution to the property values of each phase are given.

Dynamic calculation

The **Dynamic** calculation assumes the phases that exist are those predicted to be there at each temperature from a previous thermodynamic temperature step calculation. This can also be used to calculate properties when stepping in concentration when temperature is fixed.

Extended general calculation

The **Extended general** mode performs a calculation of properties vs temperature by first considering a heat treatment temperature. It is then considered that below this temperature, as for the general calculation case, the phases are "frozen in". Above the heat treatment temperature the phase amounts are allowed to change to their equilibrium values and the calculation is made as for the dynamic mode.

Solidification properties

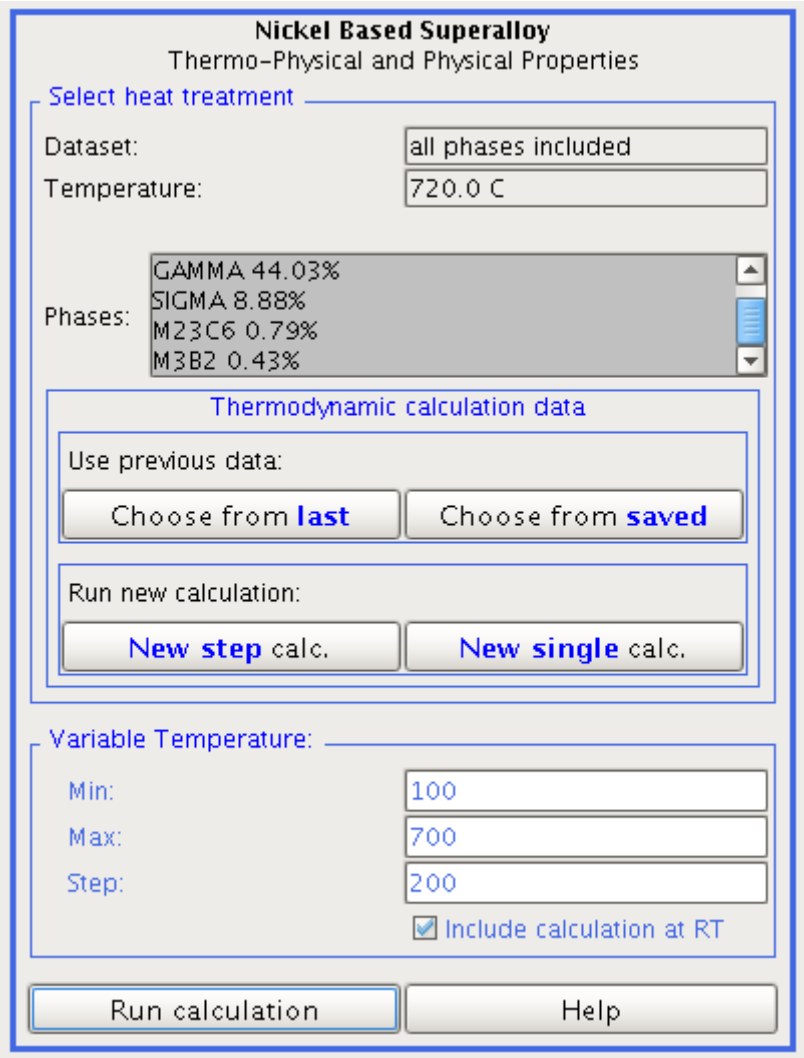
The **Solidification properties** module uses a saved solidification calculation as a basis for predicting thermo-physical and physical properties during the solidification process.

2.7.2. Physical and Thermo-Physical properties calculations.

Note:

Please read the notes on the selection of which physical properties calculation to use first.

Input:



FIRST STEP:

Select a heat treatment temperature as described here.

SECOND STEP:

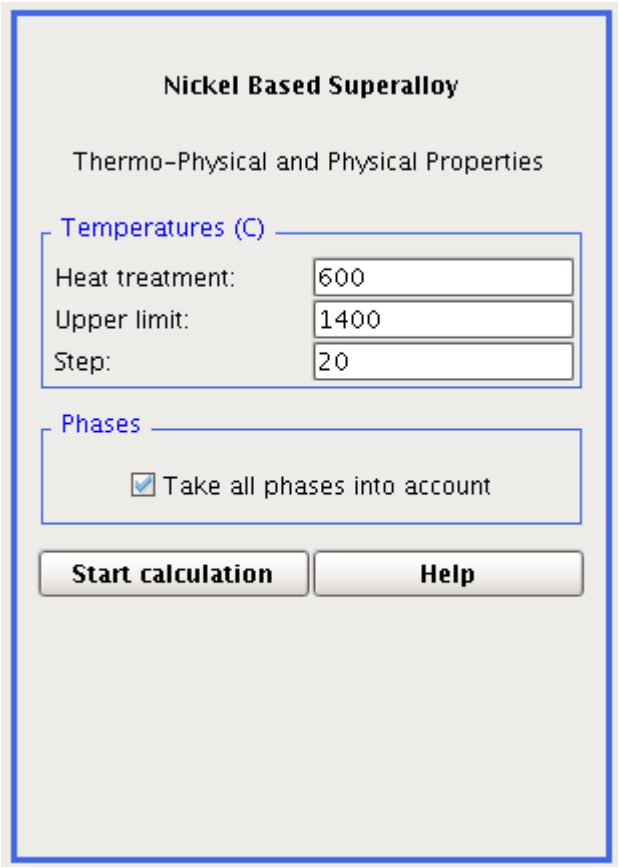
The bottom part of the window prompts you for the temperature range over which to perform the general properties calculation.
By default the **Include calculation at RT** option is selected and the properties will be calculated at room temperature.
To launch a calculation press the **Run calculation** button.

2.7.3. Extended physical and thermo-physical properties

Note:

Please read the notes on the selection of which physical properties calculation to use first.

Input:

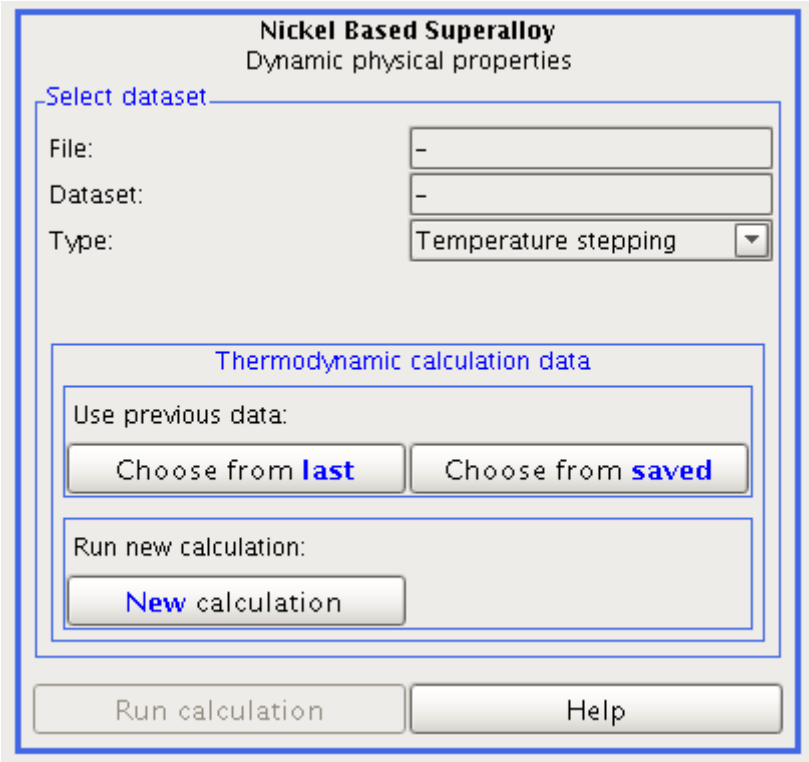


- Input the heat treatment temperature, the upper limit temperature and a step size. From room temperature to the heat treatment temperature the phase distribution in the alloy will taken as that formed at the heat treatment temperature. Above the heat treatment temperature the phases are taken to be those in equilibrium.
- By default all available phases will be included in the calculation, should you want to suspend any phases uncheck the *Take all phases into account* check box and a phase selection dialog will appear.
- The **Start Calculation** button will launch the calculation.

2.7.4. Dynamic physical properties calculation

Note:

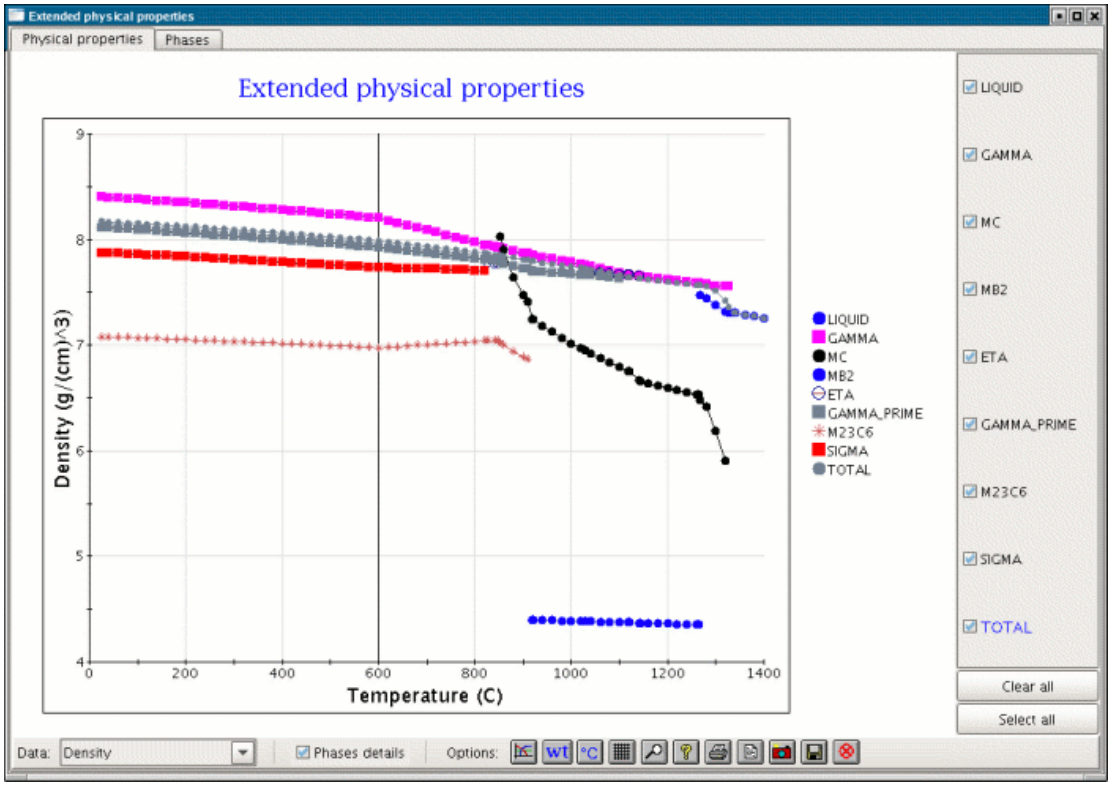
Please read the notes on the selection of which physical properties calculation to use first.



Input:

This is based on the data selection mechanism described here. However there is one more degree of liberty, the input data can not only be temperature steeping but also concentration stepping or profile. Select the appropriate type requested

2.7.5. physical and thermo-physical properties plots



- The property to be displayed can be selected from the choice box labeled *Data* located on the right side of the toolbar. The list of properties dependson the type of calculation made (properties during solification, properties after heat treatment...).
- The *Phase details* checkbox allows the display of the properties for all phases. If this box is checked, a panel with the list of phases will appear on the right for the selection of phases for which data should be displayed. The **Clear all** button will deselect everything. The **Select all** button will select everything. The selector can also be used very efficiently as a zoom tool.

Notes:

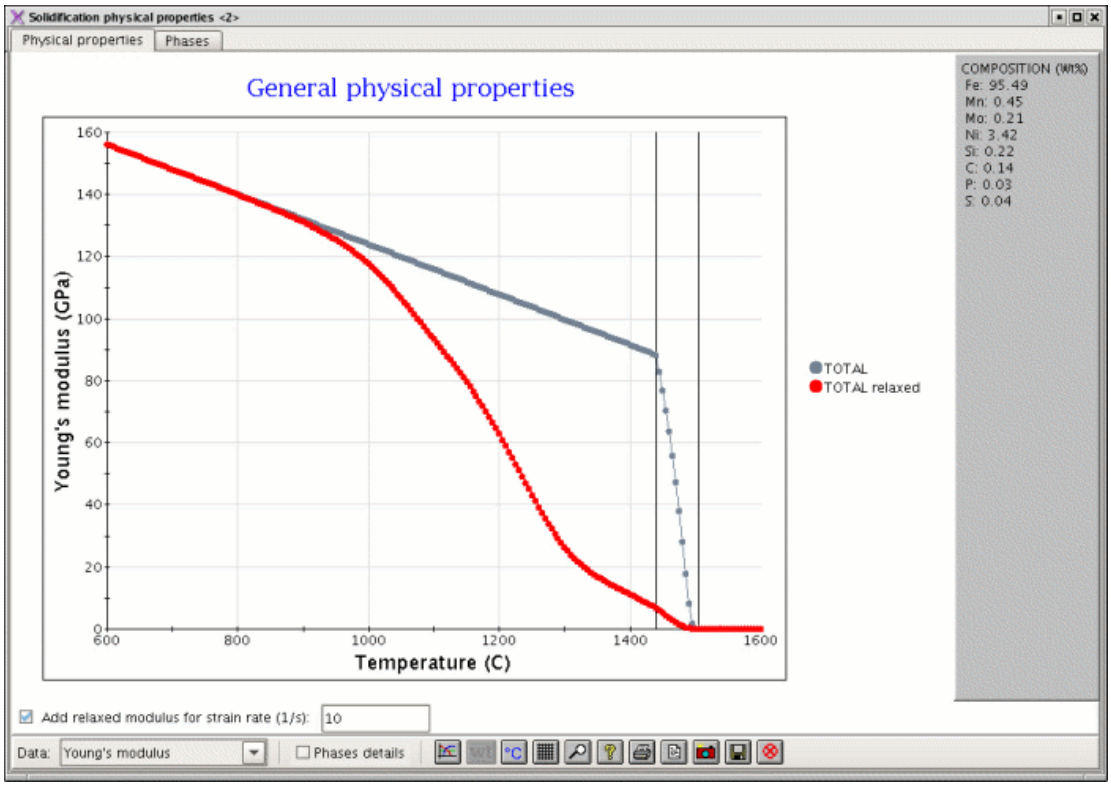
- For solification physical properties calculations, graphs contain two marker axis which correspond to solidus and liquidus.
- For physical properties calculations with a heat treatment, one marker axis is displayed to mark the heat treatment temperature.
- The panel displayed also has a **Phases** tab at the top which will display information on the phases as described here.

Other:

The other features and buttons are common to all graphs and are explained in the graphs page.

Young's and shear moduli:

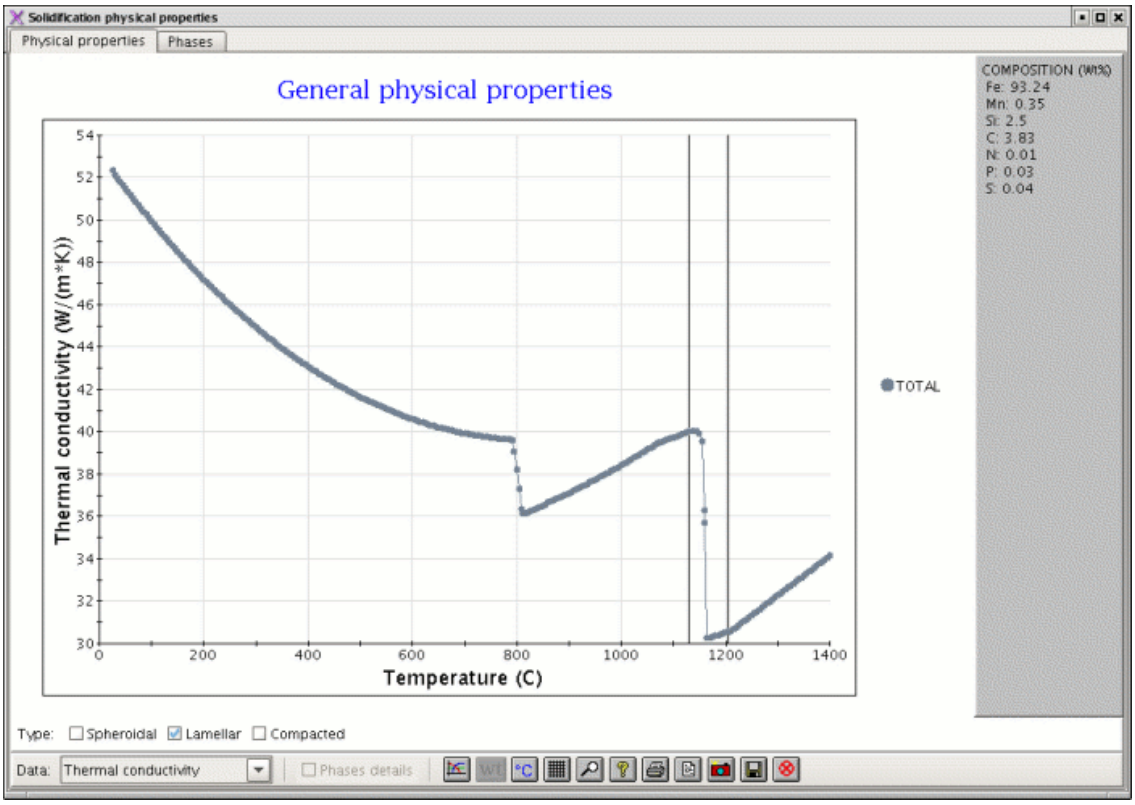
In version 4.0, the possibilility to calculate so-called relaxed has been introduced. The concept motivatiing this is that at high temperature the mechanism which governs the deformation needs to take into account...



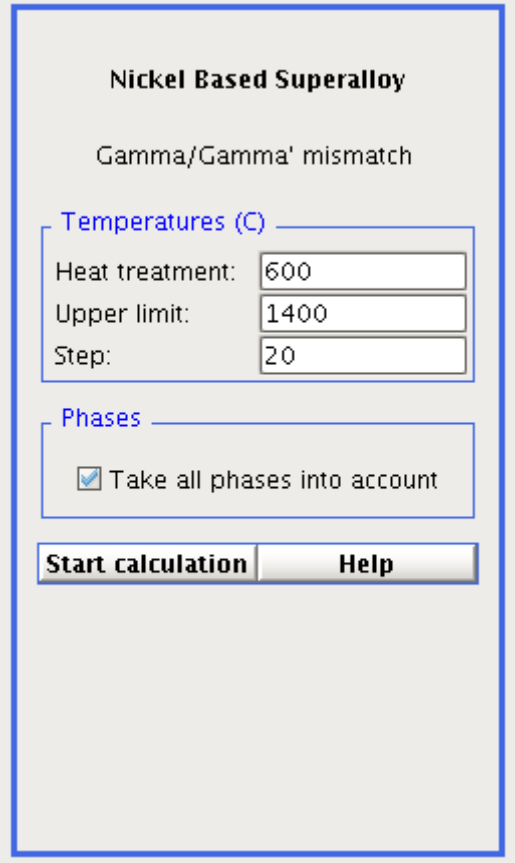
If you wish to display the relaxed modulus simply check the *Add relaxed modulus* checkbox at the bottom of the graph and input a strain rate value. The graph will be updated as the strain rate is changed.

Cast Irons:

For Cast Irons, the Graphite phase structure has to be taken into account to calculate the values of cerain properties like thermal conductivity or Young's modulus. As such for these properties, the user can select on the graph the following types: spheroidal, lamellar and compacted by selecting the relevant checkbox at the bottom of the graph.

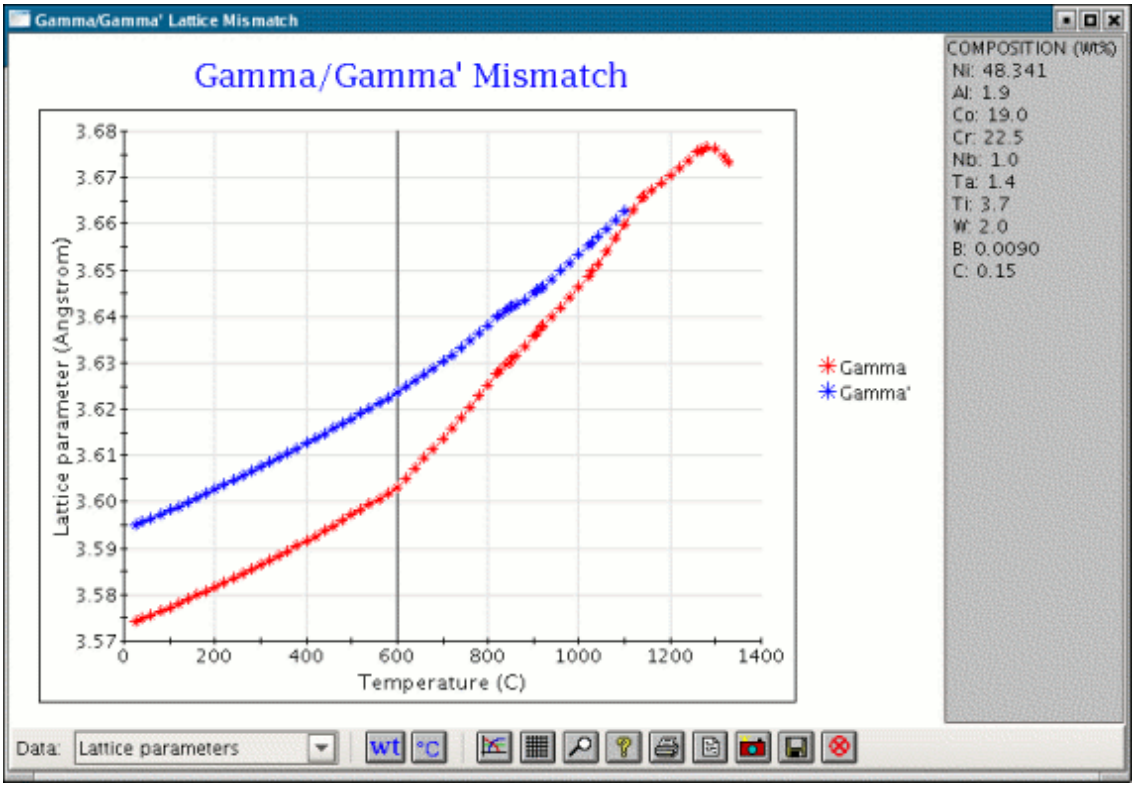

Solidification physical properties
Physical properties
Phases
General physical properties
Thermal conductivity (W/(m*K))
Temperature (C)
TOTAL
COMPOSITION (Wt%)
Fe: 93.24
Mn: 0.35
Si: 2.5
C: 3.83
N: 0.01
P: 0.03
S: 0.04
Type: Spheroidal Lamellar Compacted
Data: Thermal conductivity
Phases details

2.7.6. Gamma/Gamma' lattice Mismatch



- Input a heat treatment and upper limit temperatures as well as a step size. From the upper limit down to the heat treatment temperature the phase distribution in the alloy will be recalculated. Under the heat treatment temperature, phases will be frozen.
- By default all available phases will be included in the calculation, should you want to choose the phases to include uncheck the *Take all phases into account* check box and a phase selection dialog will appear.
- The **Start Calculation** button will launch the calculation.

2.7.7. Gamma/Gamma' mismatch plots

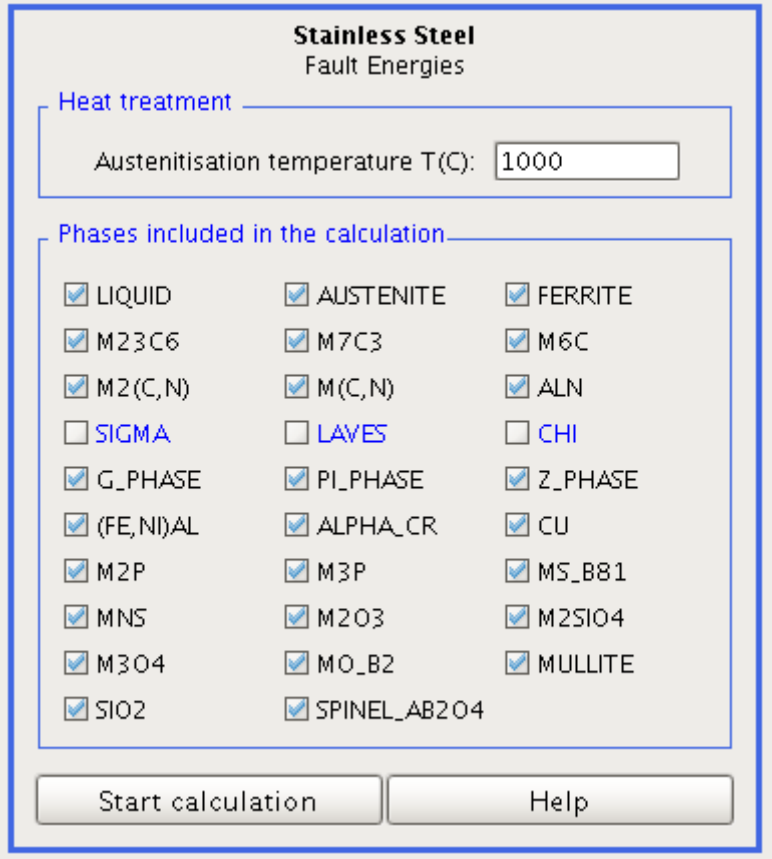


- From the choice box labeled *Data* located on the right side of the toolbar, choose to display either the lattice parameters or the lattice mismatch.
- The marker line on the graph corresponds to the heat treatment temperature.
- Two formula can be used for the calculation of the lattice mismatch. To modify the formula press the button in the toolbar and select *Change mismatch formula* item.

Other:

The other features and buttons are common to all graphs and are explained in the graphs page.

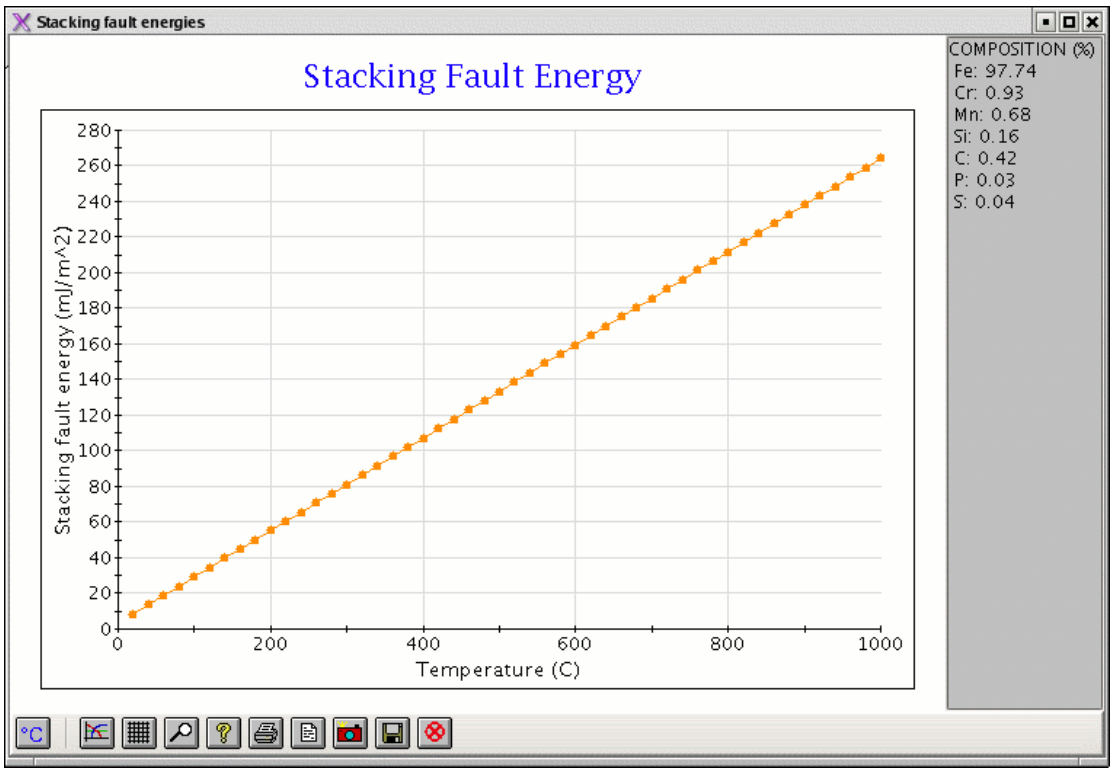
2.7.8. Stacking fault energy calculation



This module calculates the Stacking Fault Energy (SFE) between two sets of phases (typically HCP & FCC).

- Input the heat treatment temperature.
- A standard set of phases is selected to be taken into account, however it is possible to change this set by checking the list of phases displayed
- Start the calculation.

2.7.9. Stacking fault energy graph.

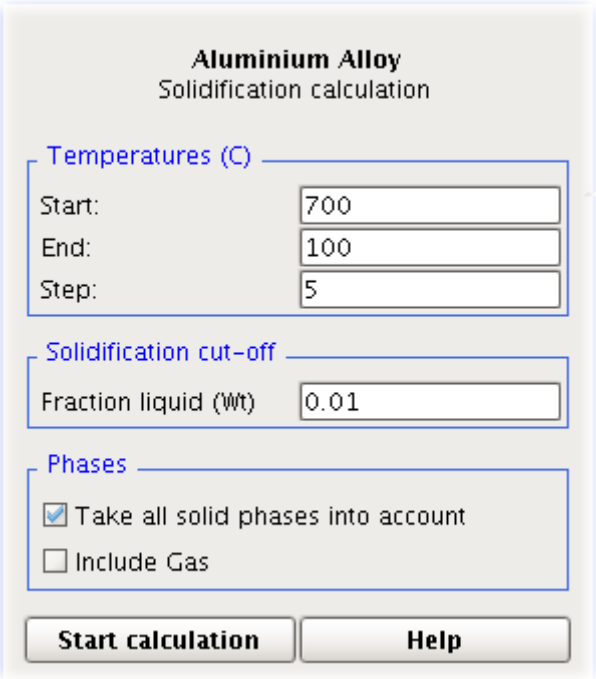


- All features and buttons are common to all graphs and are explained in the graphs page

2.8. solidification calculations.

2.8.1. Calculation window

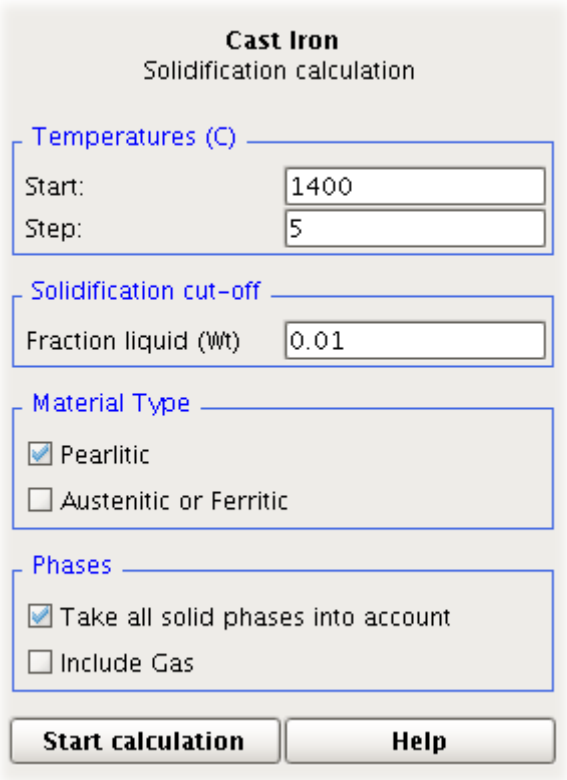
Common features:



The calculation of the phases formed during solidification is based in the Scheil-Gulliver model. For **General Steels** and **Stainless Steels** the Scheil-Gulliver model has been modified to allow fast Carbon diffusion. Once the phases formed and their composition has been calculated, the physical properties of the system are calculated.

- Enter start, end and step temperatures.
- Enter a cut-off point for solidification by giving a value for the fraction liquid remaining. For more information on which value to choose read this.
- By default all available phases will be included in the calculation, should you wish to suspend any phases, unselect the *Take all solid phases into account* box, a phase selection dialog will appear.
- Some materials have got Gas in their database list, calculating properties with Gas included will lead to peculiar results because oft its volume. As such Gas is not included by default. If you wish to included it, simply check the *Include gas* box
- The **Start Calculation** button will launch the thermodynamic solver.

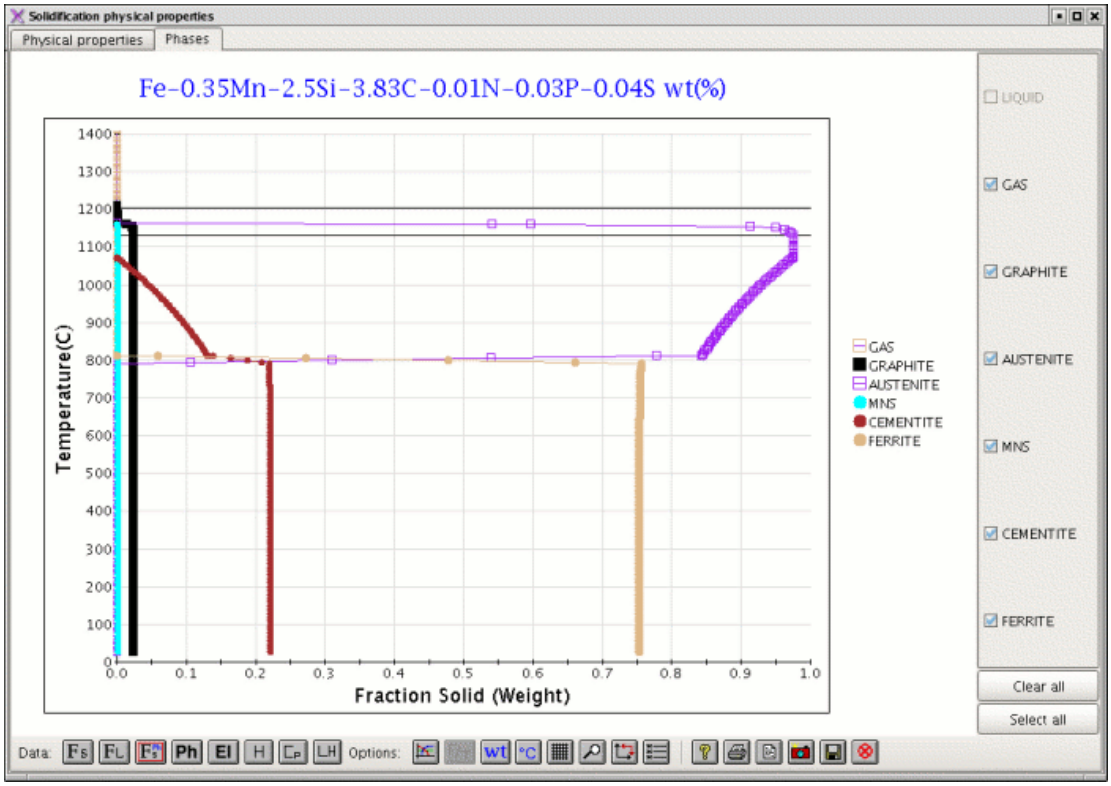
Cast Iron:



For Cast Iron, we first calculate the phases formed assuming a Scheil-Gulliver solidification model and then the solid-state transformations occuring in the Austenite formed during solidification. The two calculations are then merged to get the phase prediction. Two types of calculations are possible:

- For a pearlitic material type, Graphite formation is suspended at the end of solidification.
- For ferritic and austenitic types, Graphite formation is allowed to continue after the end of solidification is reached.

2.8.2. Solidification graphs



At the top of the graph, you will find two tabs: *Phases* and *Physical properties* which allow to choose between two graph panels.. The physical properties panel is described here. We will here describe the specific features of the Phases graph panel

The Data Buttons:

- Fs Total fraction solid vs. temperature. This is the default display when the displayer is started.
- FL Total fraction liquid vs. temperature.
- F_s^{Ph} Fraction solid of all phases vs. temperature.
- Ph Single phase analysis.
- El Single element analysis.
- H Plot (Enthalpy vs. temperature) or (Enthalpy vs. fraction solid).

- Plot (Heat capacity vs. temperature) or (Heat capacity vs. fraction solid).
- Plot (Latent heat vs. temperature) or (Latent heat vs. fraction solid).

The Options Buttons:

- Toggle between temperature and fraction solid axis.
- Normalise data to full solidification. This button is not present when the calculation has been made for a Cast Iron since for this material type, the complex nature of the calculation implies that fdata have to be normalised to full solidification.
- Toggle on and off the display of a grid on the graphs.
- Invert the axis orientation.
- Toggle the visibility of the side selector for phases/elements to be displayed.

The Elements/Phases Side Selector:

This selector gives you the choice of the elements or phases you want to appear on the current graph. Check/uncheck the various check boxes to keep or remove the phases or elements. The **Clear all** button will unselect everything. The **Select all** button will select everything. The selector can also be used very efficiently as a zoom tool. Just deselect the major phases to show only the minor phases.

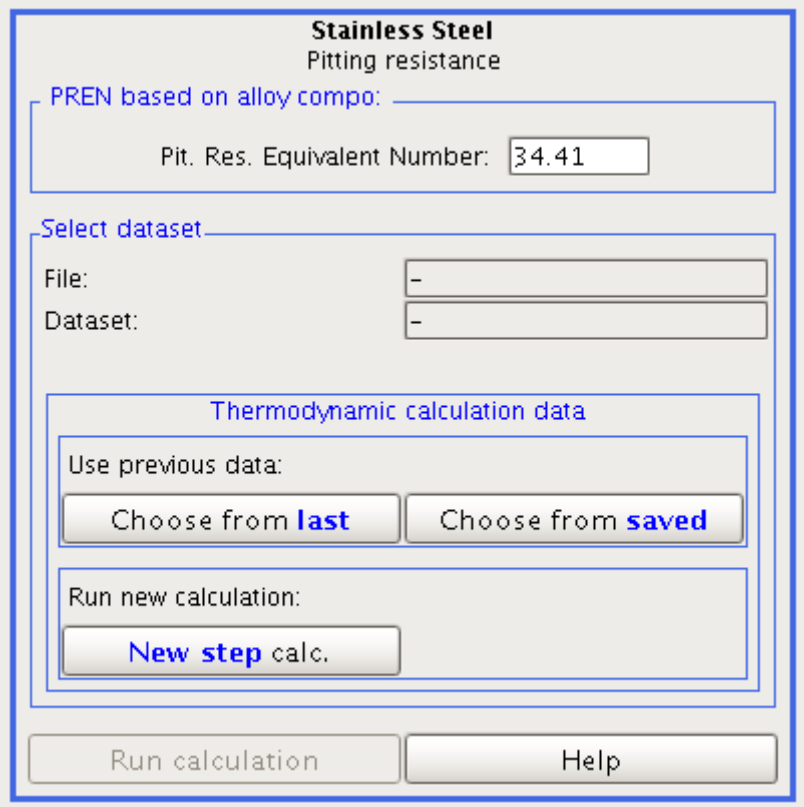
you wish not to display this selector, the buttons on the toolbar will toggle its appearance.

Other:

- The graphs contain two marker axis which correspond to solidus and liquidus.
- The other features and buttons are common to all graphs and are explained in the graphs page

2.9. Chemical properties

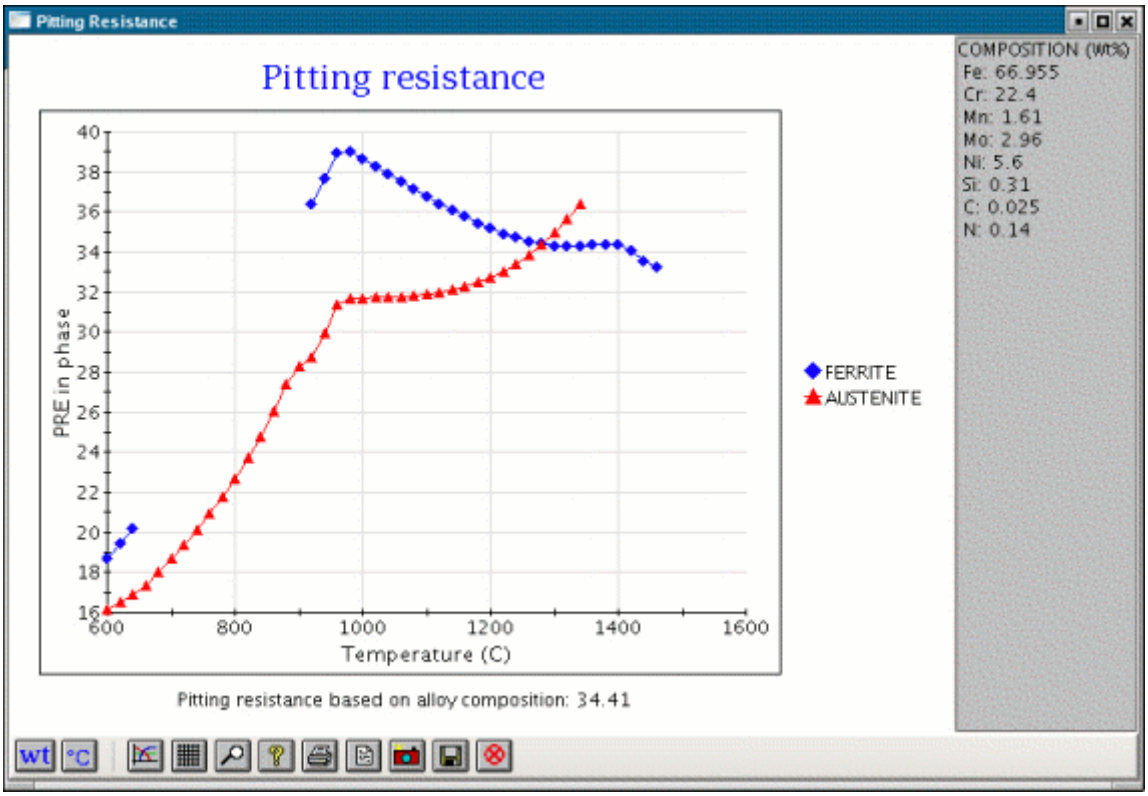
2.9.1. pitting resistance calculations.



The total pitting resistance equivalent number is displayed at the top of the panel. This number is dynamically updated as the composition of the alloy is changed.

To calculate the pitting resistance for Austenite and Ferrite, the behaviour of these two phases as a function of temperature is needed. Hence data from a thermodynamic calculation has to be selected first. The data selection mechanism described here.

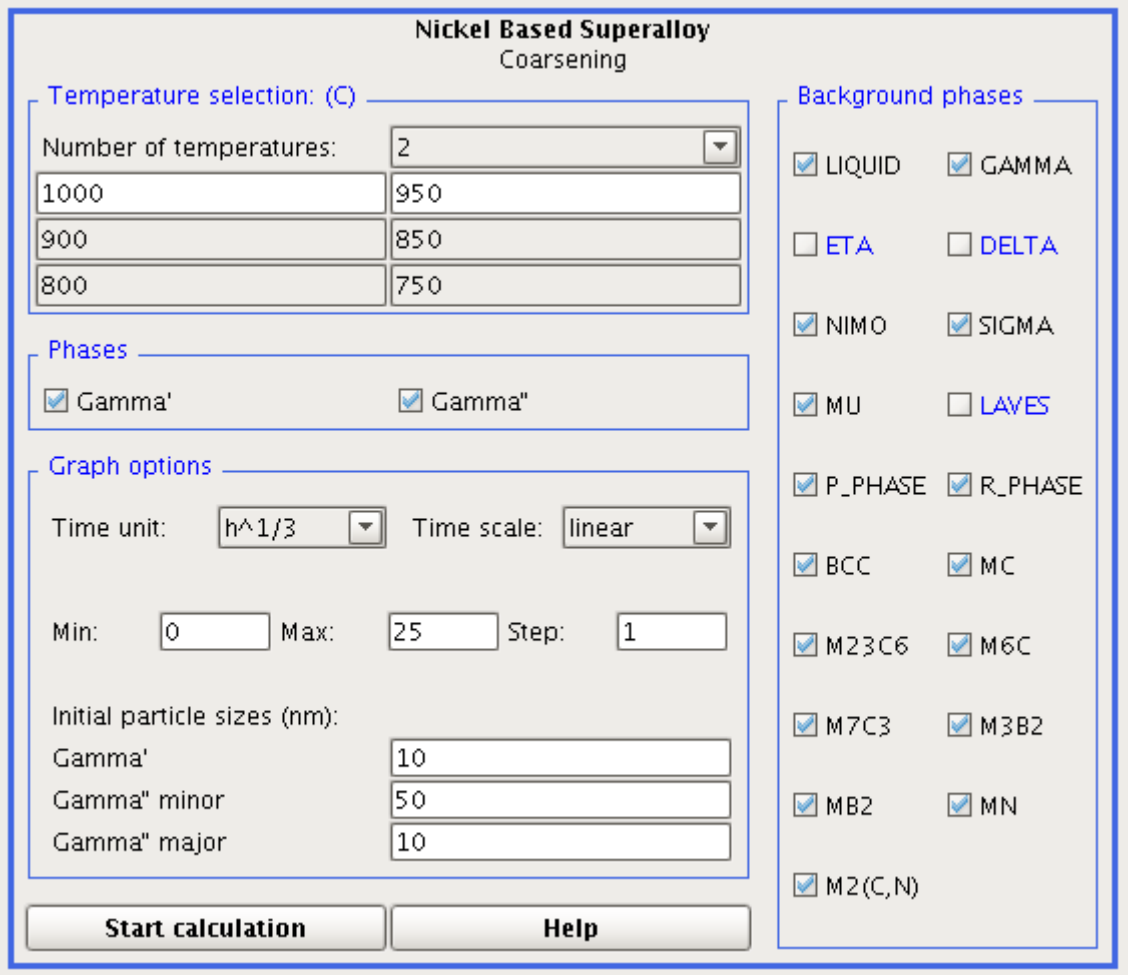
2.9.2. pitting resistance plots



All features and buttons of pitting resistance graphs are explained in the graphs page.

2.10. Coarsening

2.10.1. coarsening calculation.

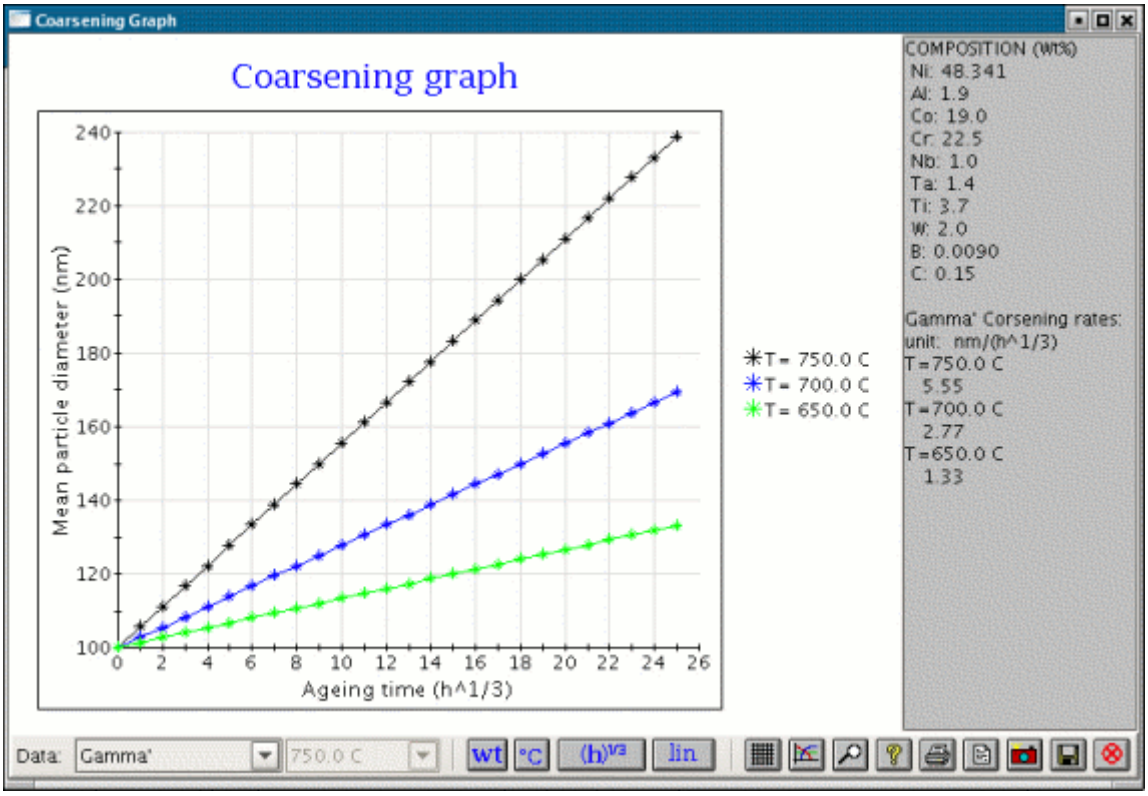


- **Temperatures**
  - Select the number of temperatures for which calculation of coarsening is required.
  - Input the temperatures values.
- **Phases** (not for single crystals)
  - Select either or both Gamma' and Gamma" for which coarsening is to be calculated.
- **Graph options**
  - Select the time unit.
  - Select linear or logarithmic time scale.

- Enter values for the minimum, maximum and step values for the time. For a logarithmic scale, minimum and maximum denote the range of decades for time (*i.e.* 10^min to 10^max) and no value for step is needed.
- Input initial particle sizes (in nanometers).

- **Background phases**
  - The coarsening calculation uses some thermodynamical calculations. The background phases are the phases to be included in these calculations. Some phases, for example eta and delta (shown in blue) are suspended by default because in alloys such as Nimonic 263 or 718 eta or delta are the stable equilibrium phases. However, because the kinetics of formation of gamma' and gamma'' are much faster they form during normal heat treatment schedules. Suspending eta and/or delta allows for this condition to be matched.

2.10.2.coarsening plots.



The Toolbar Buttons:

- The first choice box in the tool bar allows to display curves in 3 modes:
  - Gamma' coarsening for all temperatures

    - Gamma" coarsening for all temperatures
    - Gamma' and Gamma" coarsening for a single temperature. If this choice is made, a second choice box is activated to select the temperature.
-

Set the time unit.
-

Toggle the time axis scale between logarithmic and linear.

Info panel

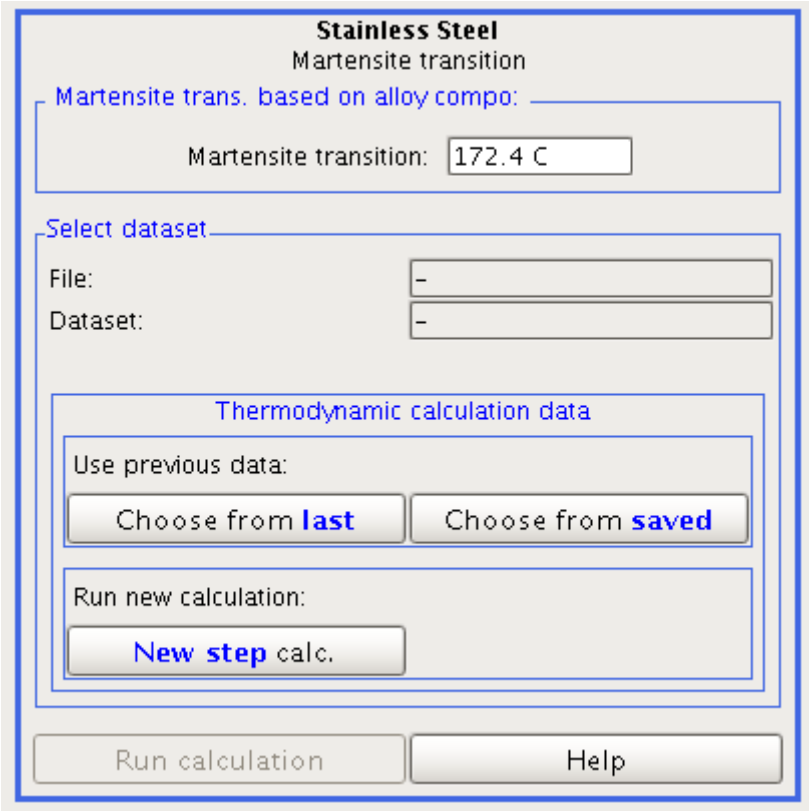
In the info panel, you will find the coarsening rates associated with the curves displayed. The time unit can be changed via the time unit icon in the tool bar.

Other:

The other features and buttons are common to all graphs and are explained in the graphs page.

2.11. Martensite transitions

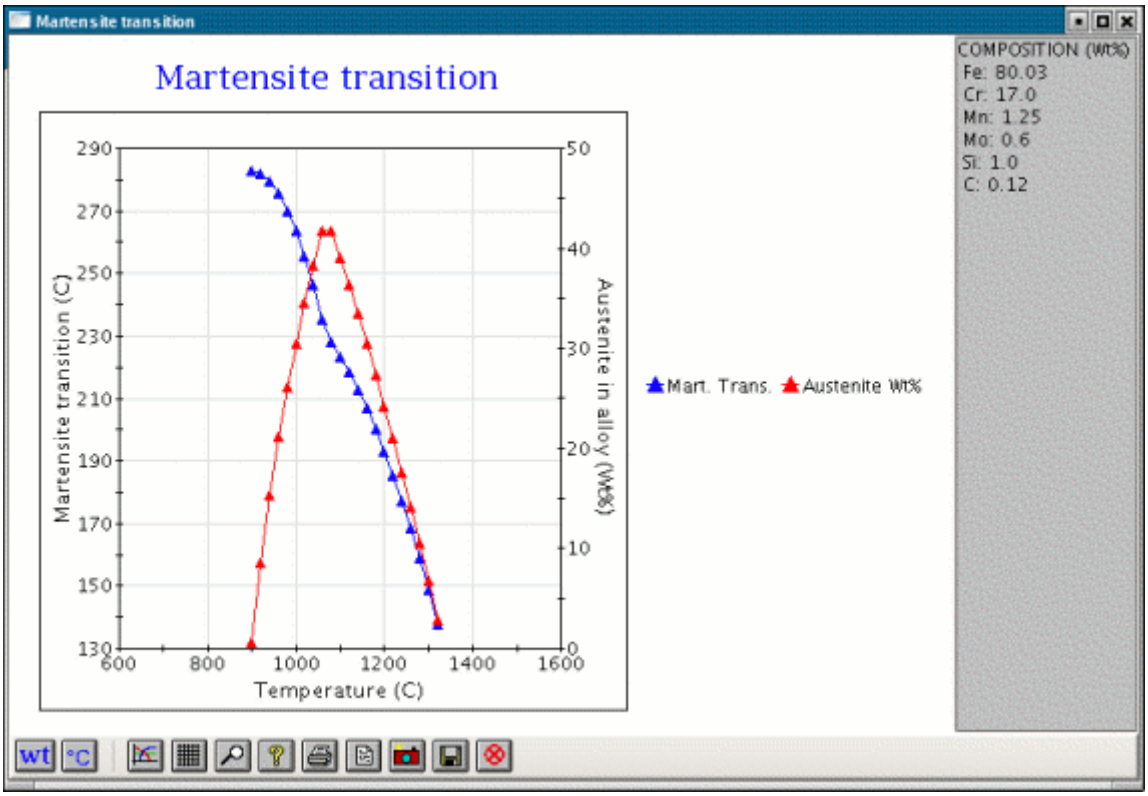
2.11.1. martensite transition calculations.



The Martensite transition calculated on the basis of the alloy composition is displayed at the top of the panel. This number is dynamically updated as the composition of the alloy is changed.

To calculate the Martensite transition based on the Austenite composition at the temperature of interest, the composition of Austenite as a function of temperature is needed. Hence data from a thermodynamic calculation has to be selected first. The data selection mechanism is described here.

2.11.2. martensite transition graphs



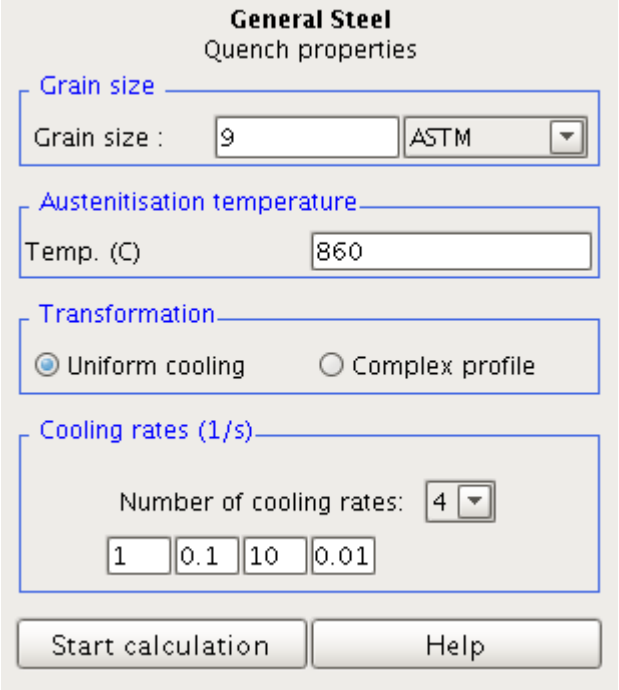
All features and buttons of Martensite transition graphs are explained in the graphs page.

2.12. Quench properties of General Steels

2.12.1. Quench properties calculation

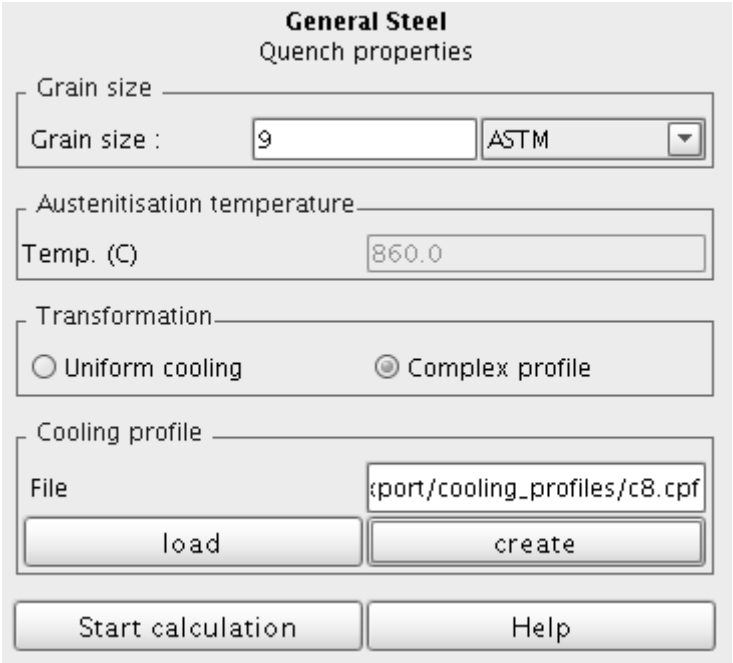
Quench properties calculation can be performed assuming an uniform cooling rate or by defining a more complex cooling profile with various cooling rates and holding times.

Uniform cooling:



- Input the grain size in Microns or ASTM.
- Input the austenitisation temperature.
- Select the number of cooling rates for which to make a calculation and input values for these cooling rates

Complex profile:

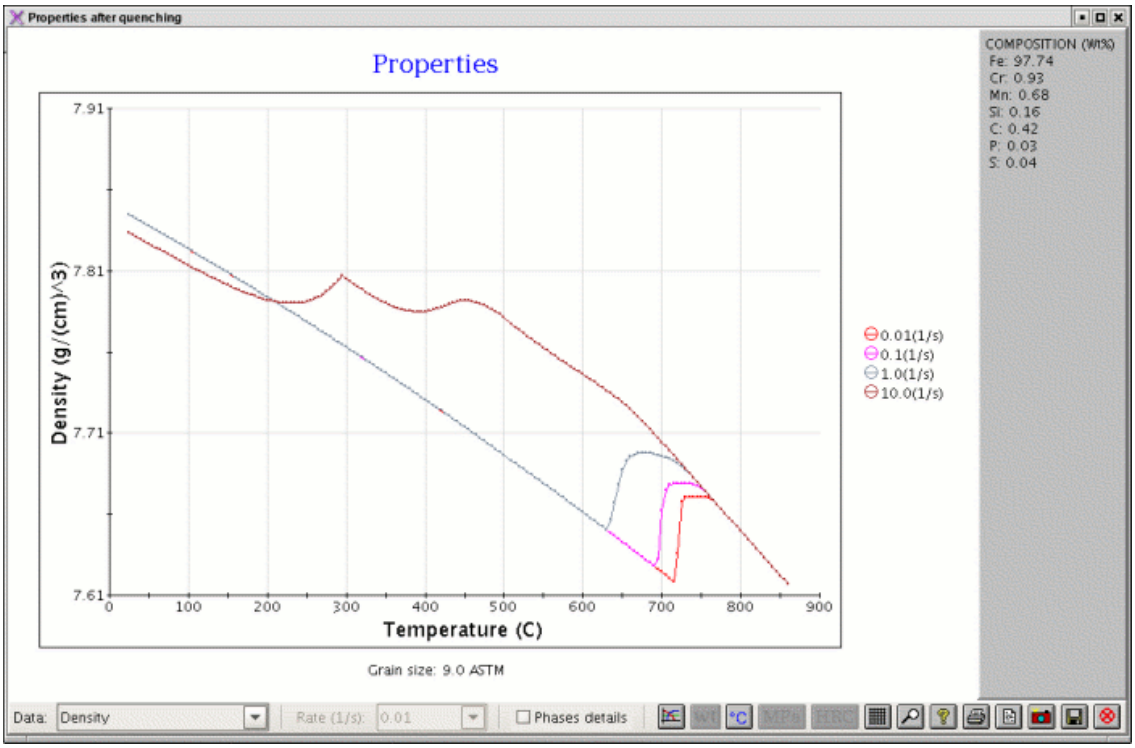


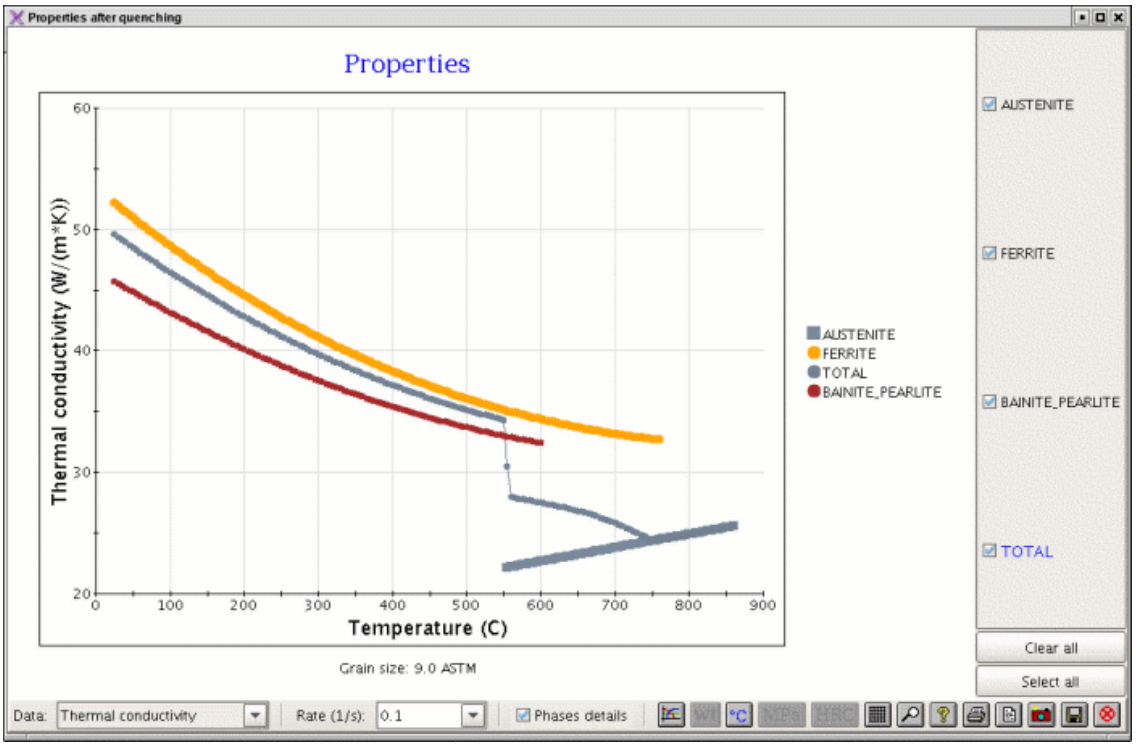
- To load a previously saved cooling profile press the *Load* button.

- To create a new cooling profile (or simply to view it) press the *Create* button. This will start a wizard which is documented here. The austenitisation temperature will be set at the start point defined in the cooling profile.

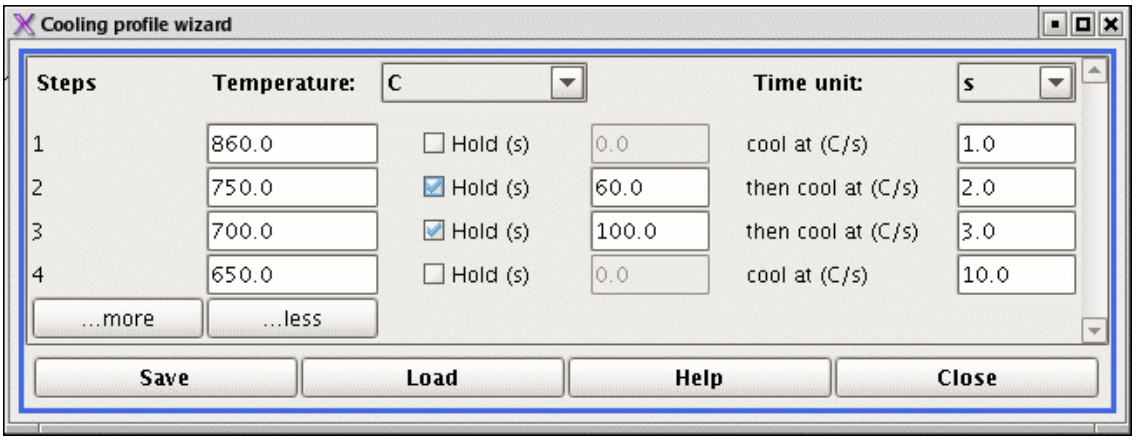
2.12.2. Quench properties graphs

Most of the features of these graphs are described here. There is however one addition here: a rate choice box in the toolbar. In order to keep the graphs clear and simple, this rate choice is linked with the *Phases details* checkbox and the property currently displayed and is not always enabled. For instance when *Phases details* is selected data will only be displayed for one cooling rate at the time which can be selected from the rate choice box.





2.12.3. The cooling profile creation wizard



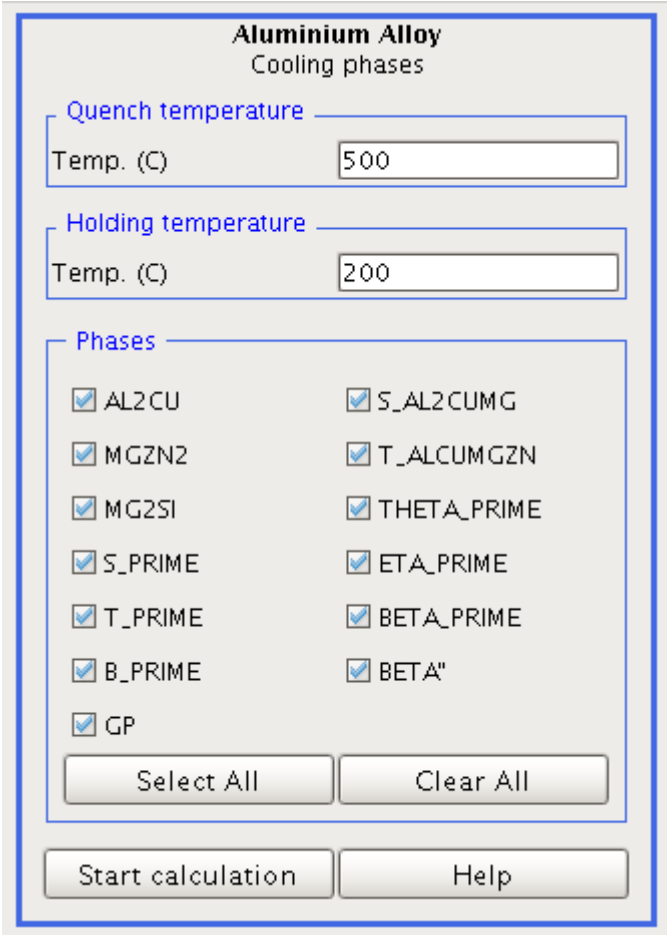
The cooling profile wizard allows to create a cooling path with variable cooling rates and holding times.

- First select the temperature and time units.
- Input the start temperature in step 1 and select the *Hold* checkbox if you want to hold at this temperture, if this is the case you also need to input the holding time.
- Input the cooling rate.
- If you want to add one step in the profile press the ...*more* button, a new line will appear and you can again input holding time and cooling rate.
- The ..*less* button removes the last step.

- The *Save* and *Load* button allows to save, re-use and modify profiles.

2.13. Isothermal tranformation

2.13.1. Isothermal phase transformation calculation

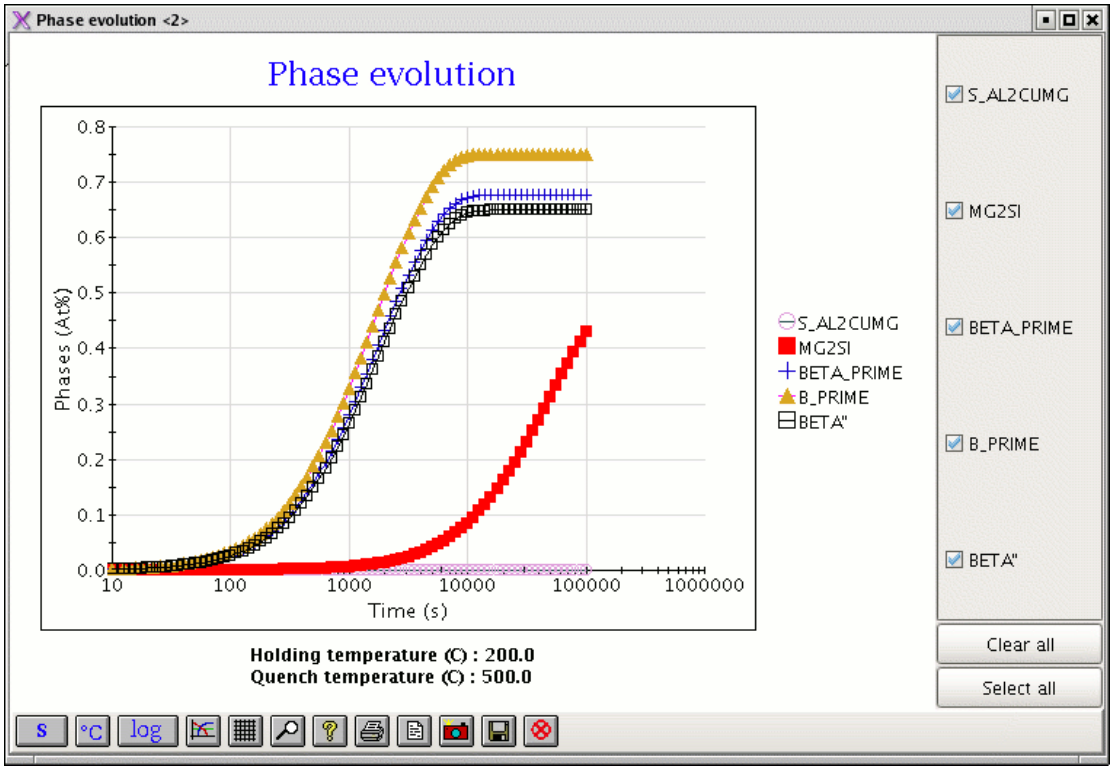


- Choose the quench temperature.
- Choose isothermal holding temperature.
- Select the phases for which to calculate the transformation.
- Press the *Start calculation* button.

The TTT, CCT and isothermal kinetic calculations are based on each phase precipitating independently from the supersaturated Al-solid solution. As such no phase competition is considered. The calculations will provide good predictions for the limiting phase that forms in all cases. When there is a clear fastest phase that forms,

good results for the amount of phase vs. time should be found for that phase in the isothermal calculations. However, if phase competition is very close some care should be taken in interpretation.

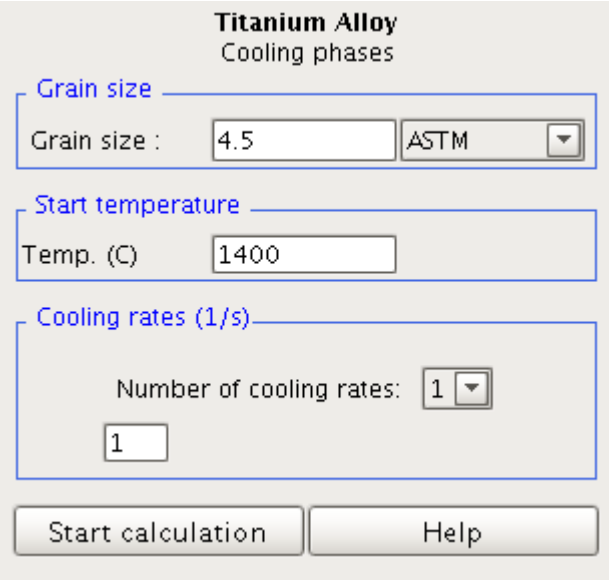
2.13.2. Isothermal phase transformation graph.



- All features and buttons are common to all graphs and are explained in the graphs page.

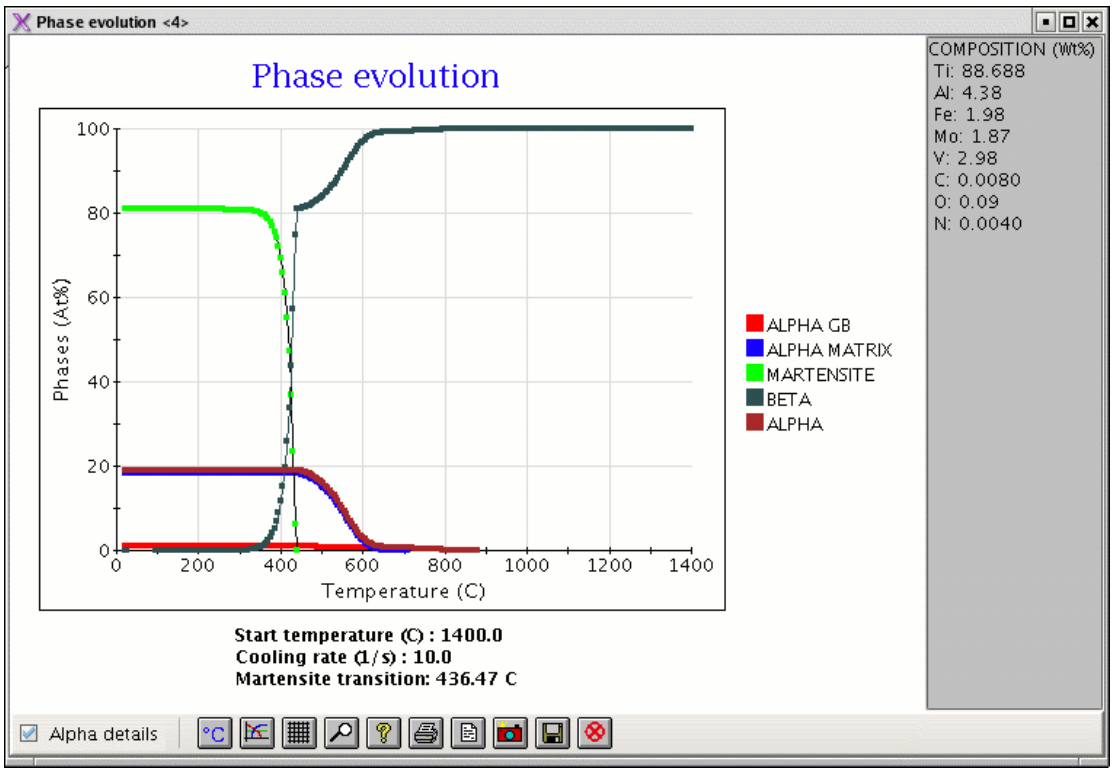
2.14. Phase formation on cooling

2.14.1. Phase formation on cooling calculation



- Choose the grain size (ASTM or in microns)
- Choose the start temperature.
- Choose the number of cooling rates to use and their values.
- Press the *Start calculation* button.

2.14.2. Phase formation on cooling graph.

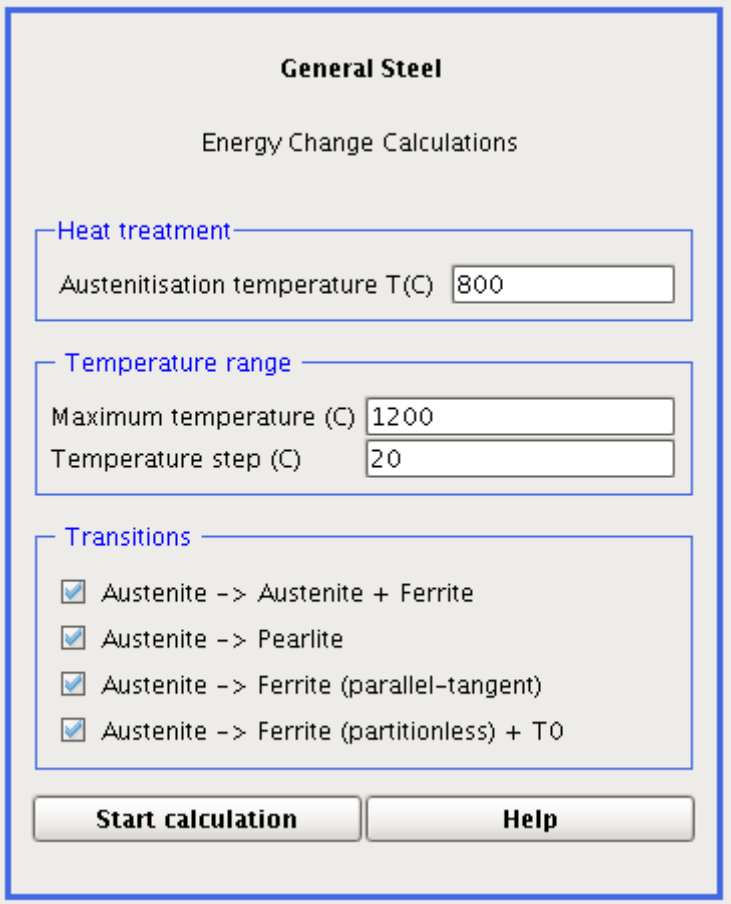


- If display of separate curves for Alpha Grain Boundary and Alpha Matrix is required, check the *Alpha details* box.
- All other features and buttons are common to all graphs and are explained in the graphs page.

2.15. Energy change

2.15.1. Energy changes calculation

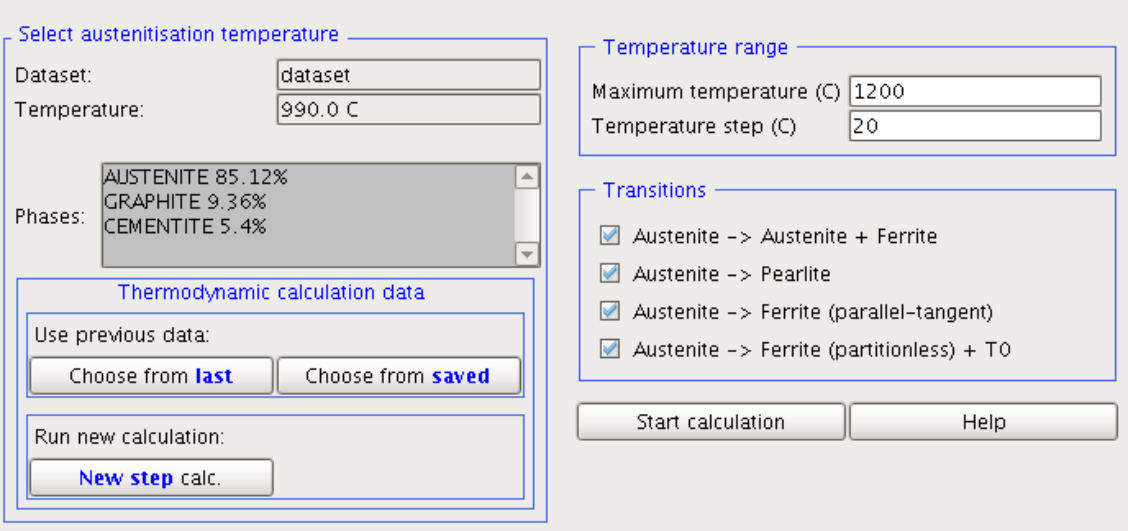
For the case of *Cast Iron* please consult this page



- Choose the heat treatment temperature.
- Choose the maximum temperature for which to calculate the energy change and the step temperature.
- Finally choose the transitions of interest. Here we show the example of transitions in a General Steel, these may be different if other alloy types.
- Press the *Start calculation* button.

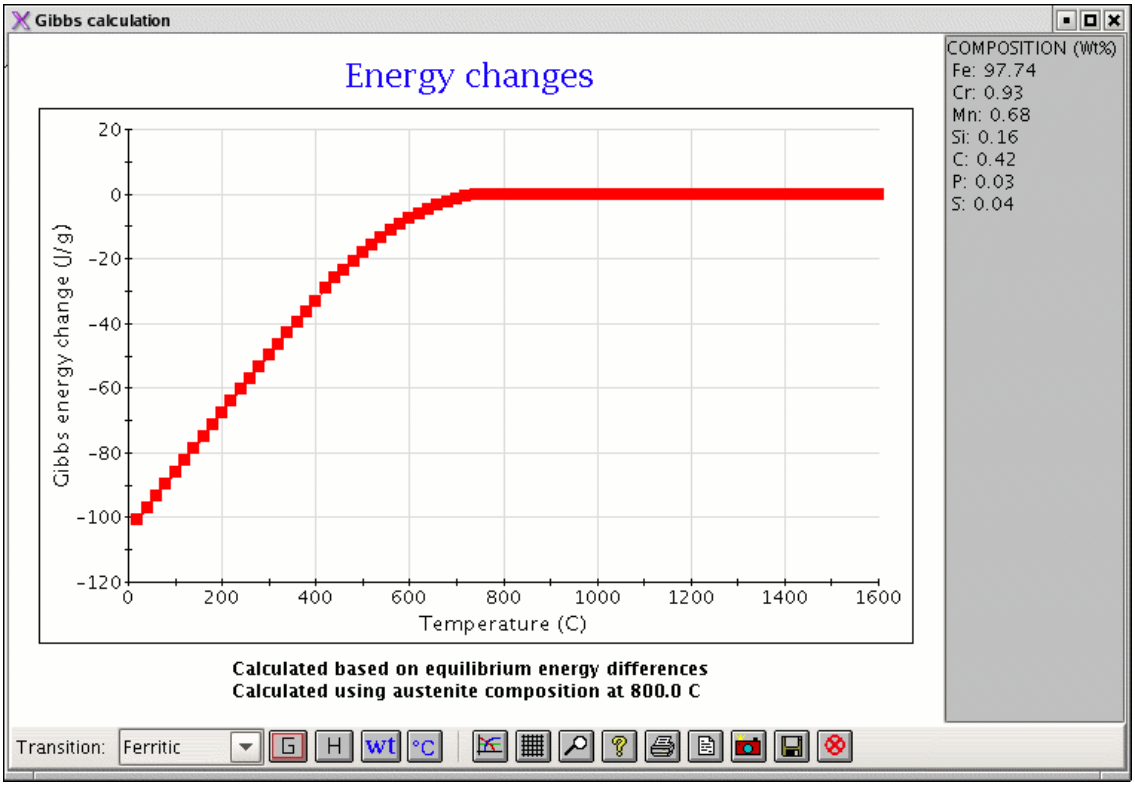
2.15.2. Energy change calculation: Cast Iron

The austenitisation temperature needs first to be chosen as described here



- Choose the maximum temperature for which to calculate the energy change and the step temperature.
- Finally choose the transitions of interest. Here we show the example of transitions in a General Steel, these may be different if other alloy types.
- Press the *Start calculation* button.

2.15.3.Energy changes graph.



- The transition type Ferritic/Austenic can be selected in the toobar.

- The display of the differences of Gibb's energy and enthalpy can be toggled with the following buttons in the toolbar:
- The other features and buttons are common to all graphs and are explained in the graphs page.

3 Material specific information

3.1. General steels calculations.

Thermodynamic calculations

Alloy carbides

As elements like Cr, Mo and Ti are added, various carbides may form, for example M7C3, Ti(C,N) etc. If alloy levels become sufficiently high, these may become more stable than cementite. In the thermodynamic calculation module, it is still possible to calculate the metastable equilibrium with cementite by removing these carbides using the select phases options.

TTT, CCT and Jominy hardenability

Alloy Carbides

If an alloy carbide (or carbides) becomes so stable that it is present during austenitisation, the TTT, CCT and Jominy hardenability calculations deal with it in the following way. Firstly, the phase equilibrium is calculated at the austenitisation temperature with the alloy carbide(s) being present. The composition of the austenite in equilibrium with the carbide(s) is then taken as the base composition for the various TTT, CCT and Jominy calculations.

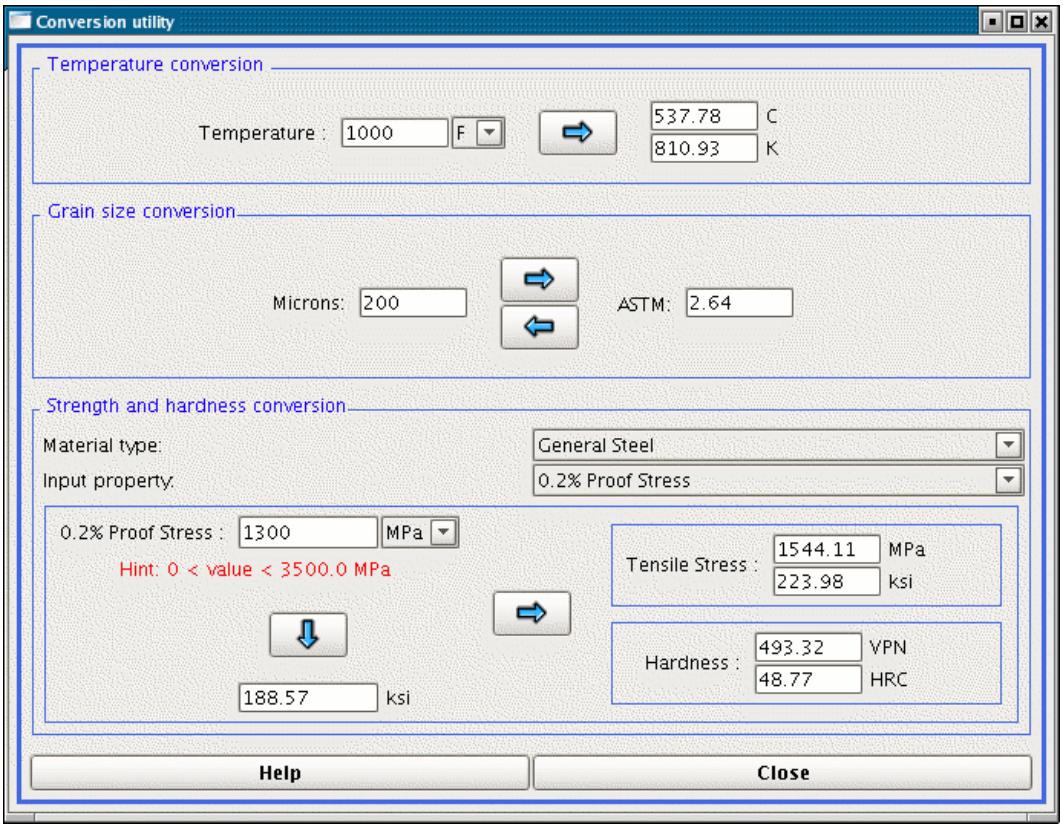
Dual phase steels

The above method of operation has a further, very significant advantage in that it is possible to make a calculation for the transformation of austenite in a dual-phase steel. In this case, the user should choose an austenitisation temperature that lies in the equilibrium austenite + ferrite phase field. The module then (1) tells you that you are in the austenite+ferrite phase field, (2) displays the amounts of austenite and ferrite in equilibrium, (3) calculates the transformation for austenite with the composition at that temperature and (4) calculates the Jominy hardenability for the mixture of ferrite formed at the austenitisation temperature + the transformed austenite

4 Utilities

4.1. conversion utility.

This tool provides a user interface for conversion between units. If the Strength and Hardness module is part of the program, conversion between 0.2% Proof Stress, Tensile Stress and Hardness are possible as well.



Temperature conversion:

- input the value
  - select the temperature unit to convert from.
  - press to trigger the conversion.
-

Grain size conversion:

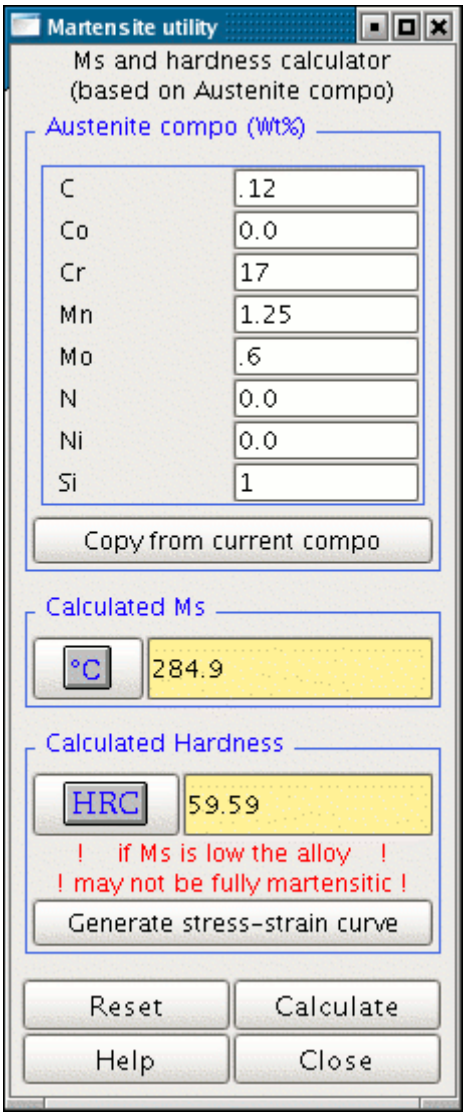
- input a value either in Micron or in ASTM.
  - press for a conversion to ASTM and for a conversion to Micron.

Strength and Hardness conversion:

- select the material type.
  - select the input property.
  - enter a value for the selected property.
  - select the unit for the input property.
  - press for the unit conversion of the input property.
  - press for the the calculation of the two other properties.

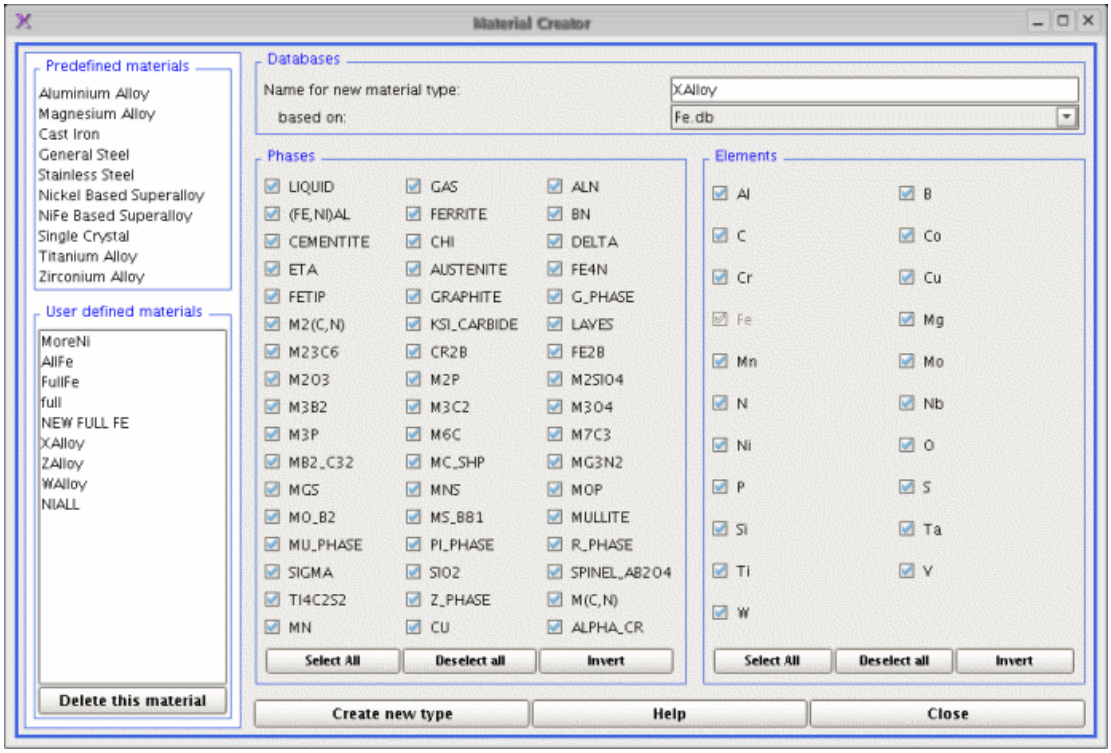
4.2. martensite transition and hardness utility.

This tool provides an utility for the calculation of the Martensite transition temperature based on the Austenite composition.



- Iput the Austenite composition in **weight %**
- The **Copy from current compo** button pastes into this window the composition currently used in the main window
- Pess the **Calculate**button to calculte Ms and hardness
- Temperature and hardness units can be toggled by pressing the units buttons
- Press the **Generate stress-strain curve** if this is required.
- **Help** brings up this help window.
- **Close** Close the Martensite calculation utility window..

4.3. new material creation.



This interface enables the creation of new material types including selected phases and elements from the databases.

1. Input a name for the new material type.
2. Select the database to use.
3. Check phases the phases to include in the material type.
4. Check phases the elements to include in the material type.
5. Press the **Create new type** button to create the new material type. If the creation is successful a window will appear to notify the success. The material browser,the materials type and options menus are updated to include the new material type.

The **Select all**/**Deselect all** and **Invert** buttons in the phases and elements panels provide quick selection/deselection and inversion of selection of the relevant entities. The left part of the window lists all available material types, predefined as well as user defined. To remove a material type which is not predefined, select its name with a mouse click and press the **Delete this material** button. Be aware that this will permanently delete everything concerning this material type: preferences, saved data, material files...

5 JMatPro's Frequently Asked Questions

Summary

1. User Interface FAQs

1.1 General questions

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1.1.2 Problems with snapshots saved to PostScript, Encapsulated PostScript or PDF formats!

1.1.3 I would like to save pictures to the GIF file format!

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1.2.1 How can I get rid of the ugly traces left by the cursor?

1.2.2 I am using Windows Millenium Edition and the vertical axis labels are badly drawn!

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2. General Steels FAQs

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7.1 have specified a specific room temperature strength but it is not the value which is ultimately calculated?

5.1. User Interface FAQs

5.1.1. General questions

1 The help files are not shown, what's wrong?

Windows: If you cannot see the Contents, FAQ,...etc files, no HTML browser like *Internet Explorer* or *Netscape Navigator* was found on your computer by JMatPro. If you cannot see the validation files, no PDF reader like *Acrobat Reader* was found. Both can either mean that the relevant applications are not installed (in which case you need to install them) or that they cannot be found because they are not properly recognised by your computer (if which case you should probably reinstall them).

Linux: Go to the *Options* menu and change the names of the applications to use, including the path if they are not at a standard location.

Please note:

i) An installer for Acrobat Reader is provided on the JMatPro installation CD. Alternatively you can download it from the Adobe website.
ii) JMatPro has a built-in HTML browser which does not use external applications, you can select it by going to the *Options* menu. However, this built in browser will not display the validation files which are in PDF format.

2 Problems with snapshots saved to PostScript, Encapsulated PostScript or PDF formats!

These problems are rooted in the third-party java library we are using to create these snapshots. We have little or no control on it and all we can do is to find work arounds. The main glitch we have come across is that pie charts exported to PS EPS or PDF have got badly defined edges and not circular.

3 I would like to save pictures to the GIF file format!

JMatPro does not provide exporting pictures to the GIF file format. Please use the PNG (Portable Network Graphics) file format instead. PNG is very similar to GIF and likewise can be imported in all good office/word processing/graphics application.

4 I would like save graphs as high quality pictures!

Exporting graphs to most of the graphic formats may result in curves or fonts which are not perfectly smooth. Higher quality pictures may be obtained saving to PostScript, Encapsulated PostScript or PDF formats.

Windows user which want to get all the benefit from these formats are advised to install the Ghostview/GSview/Ghostscript programs. These programs can be found on the CD-Rom, alternatively they can be downloaded from the Ghostscript website.

If you want to create a report including a PostScript picture:

- Open the picture with GhostView
- From the menu,select *copy*
- Go to your favourite presentation/word processing software and do *paste*

5.1.2. Windows specific question

1 How can I get rid of the ugly traces left by the cursor?

These traces are produced by fancy cursors in desktop themes. Please revert to the default cursor.

2 I am using Windows Millenium Edition and the vertical axis labels are badly drawn!

We are aware of it, but unfortunately there is nothing we can do...

3 Linux specific question

I am running JMatPro under Linux+KDE and there are screen refreshing glitches!
There are some problems with the Java Virtual Machine for Linux when the window manager used is kwin from the KDE desktop manager. We found work-arounds for the most annoying glitches but there are still a few visual problems leading to windows not well drawn, nothing serious though. We will update JMatPro as soon as fixes are released.

5.2. JMatPro's General Steel FAQ

5.2.1. For what alloy range are the calculations valid?

For thermodynamic calculations the user has access to a general steel calculation database and, as such, calculations can be made for a wide range of steels. The limitation here is that the phases are limited to liquid, austenite, ferrite, cementite and alloy carbo-nitrides. Phases such as sigma, chi, laves etc. are not included so calculations will not be applicable to high alloy steels where these phases can occur. The thermodynamic calculation module can be upgraded to provide further elements and phases. Please contact the address given in the Help-About menu item.

For TTT and CCT calculations, the software has been validated against experiment for a wide range of steels of all types. A paper describing the validation process is provided in the Help menu, under Articles & docs. There is also a paper providing validation data for Jominy calculations in HSLA steels.

5.2.2. How do I deal with Alloy Carbides?

As elements like Cr, Mo and Ti are added, various alloy carbides may form, for example M7C3, Ti(C,N) etc. If alloy levels become sufficiently high, these may become more stable than cementite. In the thermodynamic calculation module, it is still possible to calculate the metastable equilibrium with cementite by removing these carbides using the select phases options.

If an alloy carbide (or carbides) becomes so stable that it is present during austenitisation, the TTT, CCT and Jominy hardenability calculations deal with it in the following way. Firstly, the phase equilibrium is calculated at the austenitisation temperature with the alloy carbide(s) being present. The composition of the austenite in equilibrium with the carbide(s) is then taken as the base composition for the various TTT, CCT and Jominy calculations. The main effect of carbide formation at the temperature of austenitisation, is the removal of C from the austenite. The pearlite temperature can subsequently be lowered and the Ae3 increased.

5.2.3. How do I deal with dual phase steels?

The user should choose an austenitisation temperature that lies in the equilibrium austenite+ferrite phase field. The module then (1) tells you that you are in the austenite+ferrite phase field, (2) displays the amounts of austenite and ferrite in equilibrium, (3) calculates the transformation for austenite with the composition at that temperature and (4) calculates the Jominy hardenability for the mixture of ferrite formed at the austenitisation temperature + the transformed austenite.

5.3. Solidification FAQs

5.3.1. What does the solidification cut-off entry mean?

This takes into account the fact that although the Scheil-Gulliver model works well for many types of alloys, it is still an approximation and it is taken that some back diffusion will occur. The effect of the back diffusion will be (1) that some phases that are predicted to form in the very last part of the calculation will not be seen and (2) the alloy will become fully solid before 100% solid is reached in the simulation. To overcome this, we have introduced a solidification cut-off point, where it is assumed that once there is less than this amount of liquid, solidification can effectively be considered complete. It is noted that for most cases, 0.01 fraction liquid works very well. In Ni-based superalloys, it is recommended that a value nearer 0.02-0.03 is used. In the graphical output window, a correction can be applied such that solidification can be displayed as complete (i.e. fraction solid equals 1) when the solidification cut-off is reached. This is an option in the purely thermodynamic Scheil-Gulliver option, but this correction is applied in all cases when the physical property model is used.

5.3.2. How to deal with Gas?

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5.4. Creep FAQs

5.4.1. Why is there an inflexion in the creep curves?

Creep occurs under the influence of an "effective" stress, which is the difference between the applied stress and the "back" stress, which is generated by the microstructure. In the presence of particles, the back stress is determined by a different mechanism for low applied stress (climb) and high applied stress (looping). The inflexion marks the point at which there is a change in mechanism.

5.5. Lattice mismatch FAQs

5.5.1. Why is there a change in slope for the gamma/gamma' mismatch?

Below a critical temperature achievement of true gamma/gamma' equilibrium is prohibited by kinetics. The amounts are effectively "frozen in" and it is usual to assume that the amount of gamma' at the final heat treatment stage dictates these amounts. The two regimes are then, where the gamma/gamma' amounts and compositions remain frozen and the change in lattice mismatch with temperature is governed by the inherent difference in expansion coefficients between the two phases. Above the heat treatment temperature JMatPro allows gamma/gamma' equilibrium to be achieved and lattice mismatch is then governed by both the difference in expansion coefficient AND the change in composition of gamma and gamma'. Often, final heat treatments lie in the range 700-850C and it is reasonable for the above assumptions to hold. For alloys where the heat treatment temperature may be higher it may be best to assume that above 850C gamma/gamma' equilibrium is achieved and set the heat treatment temperature to this. Results above 850C should then be reasonable, however, care should be taken at temperatures below this.

5.6. TTT/CCT FAQ

5.6.1. I know a phase exists in an alloy but I can't see the TTT or CCT curve for it even though I've selected it in the TTT/CCT module?

This is a potential problem with phases that only have very small amounts in equilibrium. For example, some carbides may only have amounts of 0.2% in the alloy. The default amount for thr TTT/CCT calculations is 0.5% and, therefore, this amount can never exist. To *see* the formation of such phases re-set the amount transformed to an amount lower than the amount of phase that exists in equilibrium.

5.7. JMatPro's High temperature strength FAQ

5.7.1. I have specified a specific room temperature stength but it is not the value which is ultimately calculated?

The grain size is calculated assuming a standard strain rate of 0.02/min. If the strain rate used in the high temperature strength is different, the room temperature strength will be adjusted accordingly.